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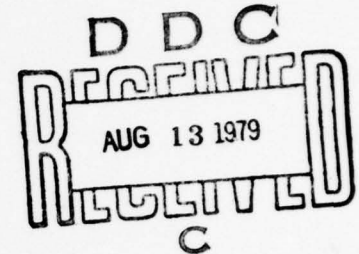
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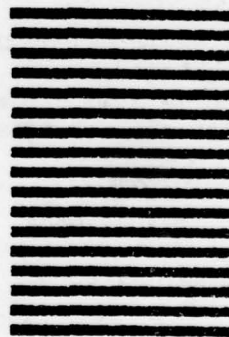
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The Department of Defense (DOD) weapon systems acquisition process has a complex and dynamic nature which continually challenges management's ability to develop effective policy to support decision-making. With the invaluable assistance of key managers within DOD, Office of Management and Budget, and Congress, a policy model of the process has been developed using the system dynamics concept. The formal and informal system structure and policies which currently exist for the weapon systems acquisition process are addressed in the research. The purpose of the dynamic policy model is to provide a tool to assist DOD strategic managers in understanding the complex nature of the system and to identify the most important areas that are sensitive to changes in either structure or policy. The model thus provides a device for policy development. ↗

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A DYNAMIC POLICY MODEL OF THE DEPARTMENT
OF DEFENSE SYSTEMS ACQUISITION PROCESS

A Thesis

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Logistics Management

By

Susan A. Kaffenberger, BS
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June 1979

This thesis, written by

Susan A. Kaffenberger

and

Captain David P. Martin

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degrees of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(Susan A. Kaffenberger)

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(ACQUISITION LOGISTICS MAJOR)
(Captain David P. Martin)

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Thomas W. Clark Jr.
COMMITTEE CHAIRMAN

TABLE OF CONTENTS

	Page
LIST OF FIGURES	vii
 Chapter	
1. INTRODUCTION	1
Overview	1
Problem Analysis	2
Problem Statement	4
Research Question	4
Objectives	5
Justification of Research	6
Scope	7
Presentation Approach	8
2. LITERATURE REVIEW	9
Introduction	9
Policy Making	9
The Acquisition Process	10
Evolution of Acquisition Policy	15
Recent Reports	18
System Dynamics Modeling	22
Overview	22
Models for Complex Systems	24
Basic Concepts of System Dynamics	26
Special Considerations for Systems Dynamics	27

Chapter	Page
Applications of System Dynamics	30
Application to Acquisition Policy	31
Summary	32
3. RESEARCH METHODOLOGY	34
Introduction	34
RESEARCH APPROACH	34
Procedure	34
Describing the System	35
System Sector Diagrams	36
Causal Loop Diagrams	36
Interview Process	37
Flow Diagrams	39
Equations	39
Model Testing and Validation	40
Analysis of the Model	42
AN EXAMPLE OF THE SYSTEM DYNAMICS TECHNIQUE	42
Causal Loop Diagrams	44
Flow Diagrams	47
Equations	48
Summary	52
4. INITIAL MODEL FORMULATION	54
Introduction	54
The Acquisition System	54

Chapter	Page
Political Sector	60
Need Sector	67
Financial Sector	75
Technology Sector	83
Weapons Systems Research and Development Management	88
Resources Sector	99
Production Sector	103
U.S. Operations Sector	106
Allied Sector	110
Enemy Sector	113
Conclusion	116
5. THE MATHEMATICAL MODEL OF THE DOD SYSTEMS ACQUISITION PROCESS	117
Introduction	117
Political Sector	118
Need Sector	130
Financial Sector	142
Technology Sector	153
Research and Development Sector	157
Resources Sector	179
Production Sector	185
U.S. Operations	192
Allied Sector	198

Chapter	Page
Enemy Sector	212
Summary	218
6. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	219
Introduction	219
Summary of Research	220
Conclusions	226
Recommendations for Further Study	232
APPENDICES	
A. INTERVIEW GUIDE	235
B. PERSONAL INTERVIEWS	239
C. COMPUTER LISTING AND FLOW DIAGRAMS	243
SELECTED BIBLIOGRAPHY	313

LIST OF FIGURES

Figure		Page
2-1	Major System Acquisition Process	13
2-2	Information Feedback System	28
3-1	System Sector Example	43
3-2	Causal Link Example	44
3-3	Polarity of Causal Chains	46
3-4	Causal Loop Example	46
3-5	Flow Diagramming Symbols	49
3-6	A Flow Diagram Example	50
4-1	Acquisition System	58
4-2	Political Sector	61
4-3	Need Sector	69
4-4	Sample Mission Capability Profile	71
4-5	Financial Sector--Programming and Budgeting	77
4-6	Financial Sector--Allocation and Expenditure	81
4-7	Technology Sector	85
4-8	Product Value, Weapons Development and Production	91
4-9	Performance, Cost, Schedule	94
4-10	Weapon System Development Sector	96
4-11	Resources Sector	101

Figure		Page
4-12	Production Sector	104
4-13	Operational Sector	107
4-14	Allied Sector	111
4-15	Enemy Sector	114
5-1	Political Sector--International Relations	120
5-2	Threat vs. Intent	121
5-3	Political Sector--Economic Issues	124
5-4	Political Sector--General Support for DOD . .	126
5-5	Political Sector--Specific Support for DOD Acquisitions	128
5-6	Need Sector--Mission Area Analysis	131
5-7	Need Sector--Force Planning	134
5-8	Financial Sector--Programming and Budgeting	143
5-9	Financial Sector--DOD Budget	147
5-10	Financial Sector--Allocation and Expenditure	148
5-11	Technology Sector	154
5-12	Weapon System Development--Planned Progress	159
5-13	Progress Versus Schedule	160
5-14	Weapon System Development--Actual Progress	162
5-15	Weapon System Development--Cost and Schedule Tradeoff	165
5-16	Cost Versus Progress Rate	166

Figure		Page
5-17	Schedule Versus Time Late	167
5-18	Weapon System Development--Planned and Actual Cost	169
5-19	Weapon System Development--Schedule Extension	172
5-20	Weapon System Development--Funds Increase	174
5-21	Weapon System Development--Product Value	177
5-22	Resources Sector--Worldwide	180
5-23	Resources Sector--U.S.	183
5-24	Production Sector--Production Process . . .	187
5-25	Production Sector--Accumulated Production .	190
5-26	U.S. Operations Sector--Inventory	193
5-27	U.S. Operations Sector--Reliability and Aging	197
5-28	Allied Sector--Inventory	200
5-29	Allied Sector--Aging and Standardization .	202
5-30	Allied Sector--Threat Assessment and Planning	205
5-31	Allied Sector--Production Capacity	209
5-32	Allied Sector--Foreign Military Sales Decision	210
5-33	Enemy Sector--Inventory	213
5-34	Enemy Sector--Threat Assessment and Planning	214

Figure		Page
C-1	Financial Sector--Investment Programming and Budgeting	254
C-2	Financial Sector--Operating and Support Programming and Budgeting	255
C-3	Financial Sector--Investment Allocation and Expenditure	260
C-4	Financial Sector--Operating and Support Allocation and Expenditure	261
C-5	Decision and Time Control	280

Chapter 1

INTRODUCTION

Overview

The Department of Defense (DOD) systems acquisition process is an important element of national policy (48:1).

The systems acquisition process is defined as:

The sequence of activities starting with reconciliation of mission needs and goals with capabilities, priorities, and resources and extends through the introduction of a system into operational use or the otherwise successful achievement of program objectives [20:3].

This definition does not consider the much broader role of systems acquisition in achievement of national goals. Secretary of Defense Harold S. Brown stated the purpose of the acquisition process is to translate our technological and productive capacity into effective military posture. Several actions he cited to achieve this goal were planning mission area needs, strengthening the domestic industrial base, and utilizing the full technological and industrial power of the National Atlantic Treaty Organization (NATO) (68:307-308). In this larger sense, the national government acts to promote the welfare of people of the United States and support the welfare of its allies in its role as a world power. In essence, the

systems acquisition process provides the bridge between the national defense industry and the United States' defense force. This force not only protects the United States and its interests throughout the world but also lends credible strength to the forces of United States allies, either through direct presence or allocation of weapon systems to allied forces (68:1-4).

Because the systems acquisition process is used to satisfy several national goals and takes a significant share of the Federal budget¹, it continually challenges top government executives' abilities to develop consistent and effective policy.

Problem Analysis

The difficulties involved with implementing effective policy were noted in many reviews and criticisms of the policies relative to the DOD systems acquisition process. Many of the recommendations offered by these studies have not provided the anticipated benefits (26:1).

For example, in the 1950s the length of time to design and develop a weapon system was considered too long.

¹In FY 79, \$12.6 billion is budgeted for Research, Development, Test and Evaluation. This is approximately ten percent of the total DOD budget, but does not include the portion of the acquisition process that is funded in Procurement Appropriation or Personnel Costs (68:15).

In order to shorten the time schedule, the concept of concurrency was instituted. Concurrency called for overlapping several design and development functions which were previously accomplished sequentially. Concurrency resulted in numerous system integration problems and redesigns, which ultimately drove up the total acquisition cost. To reverse this trend of rising costs, Total Package Procurement was instituted. This concept set a fixed price for the design, development, engineering and production of weapons systems and was implemented with the C-5A cargo aircraft. The results were not successful, as costs rose rather than decreased. Historical analysis indicates the "real" problem was not cost overruns but poorly defined requirements (26:6).

This story has been repeated several times in the systems acquisition process. It indicates management's difficulty in determining the real problems or the impact of proposed solutions to these problems (26:10). Forrester (25) indicated this behavior was common to many complex and dynamic systems. Outcomes of policy decisions often lead to unexpected results. Decision-makers work with a mental image of the system structure which includes the processes and problems which affect their jobs. These images are based primarily on intuition and human judgement. This frequently leads to incorrect decisions regarding complex systems.

Problem Statement

The counter-intuitive behavior of many social systems creates a need for more formal analysis of the policy decisional structure. The complex and dynamic nature of the systems acquisition process makes it difficult for strategic management² to determine the effect(s) of policy decisions prior to policy implementation. Given this major problem, two secondary problems result:

1. The behavior of the entire systems acquisition process is not fully understood by DOD management; and
2. Management does not have the tools to understand the acquisition process or measure the impact of its policy decisions.

Research Question

In order to address the problems stated above, the following question provided purpose and direction to this research.

²Strategic management is the most current term to describe top corporate policy making in private and public organizations. Strategic management is concerned with the long-range goals of an organization and with the appropriate course or courses of action to achieve them, considering environmental conditions, available resources, and degree of risk [75:1].

Can a policy model be developed to capture the behavior of the systems acquisition process and serve as a vehicle to study changes in acquisition policy?

The concept of policy modeling is addressed by Forrester (22). The technique requires a systematic approach to studying the system structure and relationships which link management goals and decisions to actions. The purpose of a policy model is to make the decision structure explicit. The result of this modeling provides a tool to assist management in determining the behavior and response of the system through experimentation with policy situations, issues, and changes prior to implementation of policy in the real system.

Objectives

The general objectives of this research were to develop a conceptual understanding of the complex, dynamic nature of the acquisition process, and subsequently, develop a computerized policy model which reflects the structure of this process.

The specific objectives established to conduct the research included:

1. identify the structure of the systems acquisition process;
2. isolate the interactions and influence of the components and variables within the system;

3. describe the decision structure that determines the information, money, and material flows within the system;

4. construct a mathematical model which represents the components, relationships, information flows, and decisional policies of the system;

5. develop a computerized model which can be used for policy analysis and development;

6. verify and validate that the model represents the structure and decision-making process within the systems acquisition process;

7. identify areas of sensitivity or critical issues in acquisition policy; and

8. suggest changes, if required, in the management structure of the systems acquisition process.

Justification of Research

Many recent sources have recognized the need for taking a systems approach to the acquisition process to better understand the behavior of this system.

In response to the Federal Procurement Institute's (currently Federal Acquisition Institute) desire for a conceptual model of the acquisition process, Lawson and Osterhus began to develop such a model. The results of their research provided a broad conceptual model of the acquisition process. Their recommendations included a call for further research in order to develop a complete system dynamics model (40:117).

Another advocate of further research is Robert F. Coulam. In his book, Illusions of Choice, he called for

studies to understand the influence and behavior of the total acquisition system, to identify sensitive areas and trends, and to assist in developing policies for reform and improvement (15:389).

Finally, Secretary of Defense Harold Brown stated that attention was being focused on management and policy functions of the systems acquisition process to ensure effective transformation of the limited resources into useful output products. In a major departure from past procedures, he has consolidated all functions relating to acquisition in the Office of the Deputy Under Secretary for Acquisition Policy (68:311). This move indicates that the problems of the acquisition process have not disappeared, and that a more aggregate approach should be taken to identify the structure of the acquisition process and recommend improvements.

Scope

This research develops a policy model of the DOD systems acquisition process. The research focuses on the major structural and decision-making elements which exist over time, rather than on the detailed, day-to-day operations of the system. This macro approach is consistent with the basic concepts of policy modeling. The model is intended to provide increased understanding of the basic

system behavior and can be used to assist DOD managers in policy development and analysis.

Presentation Approach

The presentation of the research generally follows the sequence of activities discussed in the research objectives. Chapter 2 develops the concept of policy within the systems acquisition process and introduces the reader to policy modeling for complex systems.

The methodology used in this research is outlined in Chapter 3. The specific approach to this research effort is discussed in the first section of Chapter 3. A system dynamics application of policy modeling is presented in the second part of Chapter 3. Readers who are familiar with system dynamics modeling may wish to omit this section.

The conceptual model of the systems acquisition process is developed in Chapters 4 and 5. Chapter 4 contains the verbal descriptions of the system relationships and major issues relative to the acquisition process. Chapter 5 contains the flow diagrams and equations which were developed into the computerized system dynamics model. Based on these results and insights gained throughout the research conduct, a summary, conclusions and recommendations are contained in Chapter 6.

Chapter 2

LITERATURE REVIEW

Introduction

The search for pertinent information related to this research effort was directed along two distinctive lines: the policy-making process for systems acquisition and the tools available for problem solving. The following sections in this chapter will address these topics individually and show how each contributes to the overall purpose of a model of the systems acquisition process.

Policy Making

A general understanding of policy making is necessary before a policy model of the acquisition process can be developed. Policy can be defined as:

. . . a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions [72:656].

In this sense, policy is a decision rule applied to select a particular course of action from the "options or means available to a decision-maker, by which, it is hoped, the objectives can be attained [49:47]."

Unfortunately, objectives are not always clear and the conditions surrounding the decision may be clouded by

multi-faceted issues and conflicting forces. Thus, effective policy making is extremely difficult, especially at the strategic level of management. Intuition, judgment and experience have long been the tools of management at the strategic level. Many times, however, these tools are quite unreliable for anticipating the dynamic behavior of complex, multi-dimensional management processes (21:99).

Despite the dynamic and complex nature of strategic level policy, Forrester claims that strategic level policy making could be understood if a formal, deliberate approach were taken to discover the true "guiding policy". He defined guiding policy as that process which captures the real nature of the decision-making framework within the total environment. Policy modeling is an excellent means to reflect the behavioral aspects of the decision-making process (21:96-101).

The Acquisition Process

In order to capture the guiding policy of the acquisition process, the role of the process within the DOD and national policy must be established. The acquisition process is a major function in the DOD which has been used to facilitate achievement of various national goals (4:81). Pressure for social programs within the last decade resulted in competition between national security

and social welfare. Despite the reduced percentage of the total budget allocated to the DOD, defense spending continues to be a major determinant in fiscal policy (48:1,233). For the fiscal year 1979, the USAF budget contains \$15.2 billion (66:107) in acquisition related appropriations. This budget, once executed, creates jobs within the DOD and the defense industry, stimulates technology, and contributes significantly to the Gross National Product and general economic growth (7:1-2).

DOD policy for acquiring major systems¹ is contained in DOD Directive 5000.1 (69). The Secretary of Defense is responsible for designating systems which must follow the policy contained in DODD 5000.1; however, managers of other acquisition programs are encouraged to use this directive to guide policy decisions. The acquisition process is broken down into distinct phases starting with the identification of mission need and finishing when production is complete. In order to proceed from one phase to the next, Secretary of Defense approval is required. These approval points are called milestones and are preceded by comprehensive reviews within the services and finally by the

¹Programs with anticipated cost of \$75 million for research, development, test and evaluation or \$300 million in production are considered for designation as major system acquisition (69:5).

Defense Systems Acquisition Review Council (DSARC). The sequencing of the process, decision points, and key elements which affect systems acquisition are shown in Figure 2-1.

Although the major decisions are made by the Secretary of Defense, program management responsibilities are delegated to the Services. DODD 5000.1 also provides guidance to the Services concerning the evaluation of need for systems, the interface with industry and educational institutions, and the type of program management (69:5-10).

DODD 5000.2 supplements DODD 5000.1 by providing the decision-making framework and reporting requirements that surround each of the four milestone reviews by the Secretary of Defense (70). Although these two directives provide the largest part of official acquisition policy, many other DOD publications contain policies dealing with specific functional areas of acquisition. DODD 5000.1 contains 26 references to other policy regulations concerned with various types or phases of systems acquisition. The diffusion of policy is even more apparent at the Service level where countless regulations provide guidance on segments of the acquisition process. In 1971, for example, an officer associated with the F-15 fighter aircraft acquisition claimed there were over 1,282 directives which applied to various phases of the weapon systems acquisition process (26:14).

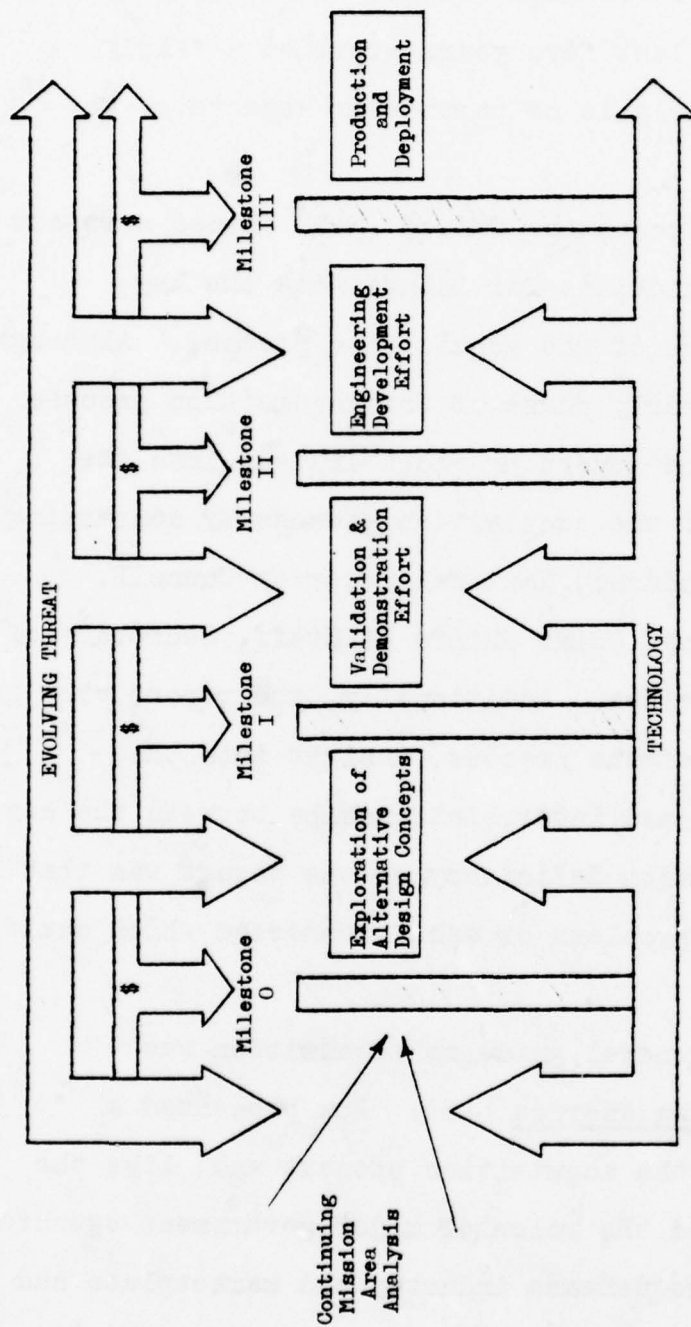


Figure 2-1
Major System Acquisition Process

In addition to the official policy, several other guidelines address the DOD acquisition. Two documents published within the last five years provided a fairly broad but thorough analysis of particular aspects of the acquisition process.

The General Accounting Office (GAO) issued a report (71) to serve as a guideline for identifying the key agencies and functions of the acquisition process. Although limited to only the early phase of the acquisition process recognized by DOD, the report provided insight into the much broader scope of the acquisition process by addressing the roles of the President, National Security Council, Intelligence Community, Joint Chiefs of Staff, Secretary of Defense, and the Services. Additionally, the report provided a description of the process, insight into the influencing factors, and interrelationships between the key participants. The major deficiency of the report was that it did not identify problems or sensitive areas which could be improved.

The second general guide to acquisition was J. Ronald Fox's Arming America (26). Fox presented a procurement view of the acquisition process and, like the GAO Report, described the roles of major government agencies. Fox also analyzed the defense industry and marketplace and

provided a long list of acquisition problems with recommended solutions. Many of these will be noted later.

Both reports contributed significantly to the knowledge about the acquisition process. However, both documents failed to address the dynamic nature of the acquisition process.

Evolution of Acquisition Policy

DODD 5000.1 was the result of 25 years of changing philosophies, needs and reforms to the acquisition process. Several categories which were the focal points of problem areas and reforms have been addressed continually throughout the evolution of the acquisition process. These primary areas included the technological, financial, contractual, and managerial aspects of the DOD systems acquisition process. In addition, the Defense marketplace relationship with DOD and its role in the national industrial base was also addressed.

During the 1950s and early 1960s, the acquisition process emphasized technical performance and short production schedules in order to meet the Soviet threat in the Cold War. Concurrency was the acquisition strategy used to provide a rapid buildup of weapons to counter the Soviet missile threat. The 1950s era was characterized by poorly

defined requirements, cost growth, poor performance, duplication and overlap of programs among the Services, and high turnover of personnel (6:68).

As a result of extensive research efforts by DOD, Congress and civilian researchers concerning the economic aspects of the weapon systems acquisition process, many reforms were instituted in management, training, performance of contracts, and accountability within the DOD (6:69). Secretary of Defense Robert McNamara sought to reverse the trend towards increasing costs of acquisition by improving program planning and selection, instituting innovative management and contracting technology, and reforming the budgeting process. Secretary McNamara was well known for the successful implementation of the Planning, Programming and Budgeting System (PPBS). PPBS centralized financial management, increased planning efforts, and emphasized management aspects of acquisition.

After several years of sustained effort, however, serious cost, schedule, and technical performance problems continued to disrupt the acquisition process [26:2].

The C-5A cargo aircraft and F-111 fighter aircraft programs were products of the McNamara era. Total Package Procurement was a major disaster on the C-5A. Prime contractor costs rose so significantly that the C-5A fixed-price contract was amended to cover a projected \$500

million loss. However, cost was a minor problem when compared to the technical difficulties with cracks in the aircraft's wings (26:3-4).

In late 1969, two promising actions were taken towards acquisition reform. First, the Blue Ribbon Defense Panel was commissioned by Secretary of Defense Melvin Laird in July 1969. The purpose of the panel was to examine very broad areas related to defense acquisition and management. Second, the Commission on Government Procurement was created by Congress in November 1969 to study and recommend methods of improving procurement (32:3-4). These studies were considered to be the first systems approaches taken to investigate the acquisition process.

The results of the Blue Ribbon Defense Panel were disappointing, since the panel did little more than restate obvious facts and provided few new recommendations for improvement. The Panel did point out several noteworthy items: requirements determination was unstructured and uncoordinated, the Office of Secretary of Defense decision process lacked any meaningful review, and the program manager had no clearly defined responsibility (32:4). Other findings included a lack of training and continuity in the program management task and a complex bureaucratic source selection process which hindered making timely, objective decisions (26:191,270). As Fox stated:

While the panel successfully identified several problem areas in the procurement process, their report did not explain why previous recommendations along the same lines have never been successfully implemented. Many procurement officials in the Defense Department are, after all, aware that the present system has faults. But despite a steady succession of studies and recommendations, the procurement process has remained impervious to structural reform [26:457].

The second study, the Commission on Government Procurement, looked at procurement in broad terms to identify consequential problems instead of focusing on the surface issues. The Committee's work was summarized in 12 major recommendations which formulated a systems approach to improve the acquisition system. These 12 points could be summarized in four basic aims:

1. Establish a common framework for all involved organizations to have a common set of procedures;
2. Define the role each organization must play;
3. Give Congress and agency heads the needed information to make key decisions; and
4. Improve the means for public accountability rather than have a burdensome administrative reporting and surveillance procedure (6:92).

Recent Reports

Since the Committee on Government Procurement's final report in 1972, the GAO has monitored the progress towards implementation of the recommendations. Of the 57 recommendations calling for legislation, only seven have

become law, 21 are pending, and 29 have not been acted upon (51:4-5). Progress has been slow.

One of the most positive actions is the implementation of Office of Management and Budget (OMB) Circular A-109, Major Systems Acquisition, and the formation of the Office of Federal Procurement Policy (OFPP), both off-shoots of the Commission on Government Procurement. OMB Circular A-109 has received affirmative response from the DOD, Congress, and the defense industry. The basic principles found in OMB Circular A-109 are:

1. Validated Mission;
2. Comparison of Alternative Systems;
3. Reliance on the Private Sector;
4. Maintenance of Competitive Opportunity;
5. Integrated Government Action; and
6. Equation of Authority and Responsibility

(51:6).

The basic intent of OMB Circular A-109 was incorporated into the 1977 revision of DODD 5000.1. However, the reform is not without critics. Major points for concern are in the area of research and development funding (34:2), extended production leadtime (9:7; 52:4), and loss of flexibility as bureaucratic implementation procedures are formulated (51:8).

Additional concern was addressed by the Defense Science Board Task Force on the acquisition cycle. Their report focused on the lengthening "front end" of the acquisition process. They concluded that the system was highly structured, costly, and lacked the sense of urgency for acquiring or modifying weapon systems for national defense. Their recommendations included a flexible implementation of OMB A-109 with special emphasis on reconciling mission requirements, and priorities with resource constraints (17).

The recent policy changes in DODD 5000.1 and OMB Circular A-109 appear to be in the right direction. However, many authorities still recognize a resistance of the acquisition process to respond to reform. A recent GAO report stated that major acquisitions at completion cost 72 percent more than the initial estimates. Technical difficulties, inflation, faulty planning, poor management and poor cost estimating were offered as major causes of cost growth (70:1).

Why do the same problems recycle? Why do new problems appear as the result of "fixes" to old problems? Perhaps the "real" problems are not really understood. Coulam offered an explanation for the recurrences of problems by indicating the chosen solutions have failed to evaluate all the influences of the process (15:5).

Coulam used two paradigms to explain the acquisition process. The first paradigm is the analytical or "Rational Man". This concept assumes that Man has complete information in the decision-making environment and selects the alternative which provides the highest payoff. Coulam noted that despite the inapplicability of the Rational Man concept to many real situations, it is continually used to make policy decisions and develop plans (15:6).

The second paradigm is the cybernetic model. This approach recognizes that Man is not perfect. Man does not have or seek complete information and filters the information he receives. One of the reasons offered for the cybernetic paradigm was that individuals and organizations cannot deal with complex problems. Therefore, the problems are broken down into smaller pieces (15:25-27). This fragmented, but highly structured approach leads to suboptimization at lower levels of the organization and places an enormous integrative responsibility on the strategic levels of the organization. The complexity of this integrative process simply furthers ambiguity in the management process (15:338).

The close of Coulam's book paints a gloomy picture for the future. However, despite this prediction, he called for reform of the total acquisition process after the behavior of the system is fully understood:

It is folly to speak of reforming the acquisition process without understanding the influence and behavior of the many organizations to be changed, yet in fact reform efforts have been forced to proceed without much detailed understanding. Partially as a result, past reform efforts have concentrated on the manipulation of conspicuous summary features of the process, like contract types, which, our study and others suggest, are not likely to be fruitful avenues of reform. Successful reform will require sensitivity to complex details of behavior in the acquisition process. Future studies can aid reform efforts by providing knowledge of these details [15:389].

Lorette suggested a means to study the acquisition process to uncover the true nature and behavior of the process. He called for a new and different approach in determining the style and conceptual relationships that encompass the acquisition process. He recommended the scope of the research include the basic philosophy of government and democracy, the political and economic systems, in addition to areas traditionally considered as part of the DOD systems acquisition process (43:6). In essence, Lorette suggested a systems approach to the acquisition process. The next section contains a discussion of a means to apply the systems approach to the acquisition process: system dynamics modeling.

System Dynamics Modeling

Overview. The quest for a methodology to solve complicated problems has always been a major objective of man. Throughout history several methods have evolved to better solve

problems. Prior to the seventeenth century, man attempted to solve problems almost entirely by deductive methods. Philosophers such as Plato, Aristotle, and Euclid sought to solve complex problems by drawing analogies from everyday life experiences. This method often yielded erroneous results (47:4-5).

In the seventeenth century, English philosopher and scientist Sir Francis Bacon led a movement toward a more structured scientific approach. In his book, Novum Organum, Bacon proposed a method for observation and logical deduction which allowed man to solve problems more effectively. This method embodied four steps:

1. Observe a physical system;
2. Formulate a hypothesis that attempts to explain the observations;
3. Predict the behavior of the system based on the hypothesis by using mathematical or logical deduction; and
4. Perform experiments to test the validity of the hypothesis (47:5).

Beer advocated use of the scientific method to solve problems; however, he stated that many times the wrong problems are solved because the boundaries of the system did not encompass the whole problem (3:50,92). The systems approach provides a vehicle to expand the boundaries to include the entire system environment.

Russell Ackoff describes the approach as follows:

The systems approach to problems focuses on systems taken as a whole, not on their parts taken separately. Such an approach is concerned with total-system performance even when a change in only one or a few of its parts is contemplated because there are some properties of systems that can only be treated adequately from a holistic point of view. These properties derive from the relationships between parts of systems: how the parts interact and fit together [1:27]

Churchman adds to Ackoff's description by including considerations for the management and resource subsystems which affect the performance of the components and the entire system (12:29-30). The systems approach has become a critical part of contemporary management science models (1:27).

Models for Complex Systems

The term model is used to denote "a simplified representation or abstraction of reality [63:19]." In this context, any system used to aid a manager in decision-making can be considered a model.

Planners deal continuously with models
They may not be aware that they are using a model,
and their models are not necessarily correct. They
are simply constructs to substitute in our thinking
for the real system that is being represented [47:8].

In Industrial Dynamics Forrester stated management science has developed a number of models to assist managers in solving problems; however, few of these techniques provide a basis for dealing with complex problems of

strategic management. Much of management science's achievements have dealt with the lower levels of the management structure (21:3). He challenged the future manager to improve his ability to handle major problems at the strategic level of management. To do this, Forrester prescribed system dynamics--a simulation modeling approach. This technique combined the systems approach to complex, dynamic management situations with the capabilities of digital computers. It provided a single framework for integrating the functional areas of management and offered a vehicle to determine how information and policy create the character of an organization. In essence, system dynamics models are "management laboratories" (21:vii).

The basic premises of the system dynamics technique are:

1. Decisions in management and economics take place in a framework that belongs to the general class known as information-feedback systems.

2. Intuitive judgment is unreliable about how these systems will change with time, even with a good knowledge of the individual parts of the system.

3. Model experimentation is now possible to fill the gap where judgment and knowledge are weakest--by showing the way in which the known separate system parts can interact to produce unexpected and troublesome overall system results.

4. Enough information is available for this experimental model building approach without great expense and delay in further data gathering.

5. The "mechanistic" view of decision-making implied by such model experiments is true enough so that the main structure of controlling policies and decision streams of an organization can be represented.

6. Systems are constructed internally in such a way that they create for themselves many of the troubles that are often attributed to outside and independent causes.

7. Policy and structure changes are feasible that will produce substantial improvement in industrial and economic behavior; and system performance is often so far from what it can be that initial system design changes can improve all factors of interest without a compromise that causes losses in one area in exchange for gains in another (21:13-14).

Basic Concepts of System Dynamics

The term system, as it is used in system dynamics refers to:

. . . a set of objects together with relationships between the objects . . . connected or related to each other and to their environment in such a manner as to form an entity or whole [56:238].

In system dynamics, the principle foundation is the information feedback loop (21:14). It is the information feedback loop which ties the objects of the system together so that it acts as an entity. Without information feedback, systems operate as uncontrolled devices where outputs are isolated from and have no influence on the inputs (23:1-5).

The information feedback loop is the part of the system that reacts to the environment. This reaction results in a system decision which ultimately changes the

environment and influences future decisions (21:14). An example of an information feedback system is depicted in Figure 2-2.

Information feedback systems contain three basic behavioral characteristics: structure, delays, and amplification (21:15). Forrester explained these characteristics as follows:

The structure of a system tells how the parts are related to one another. Delays always exist in the availability of information, and in taking action on the decisions. Amplification usually exists throughout such systems, especially in the decision policies of our industrial and social systems. Amplification is manifested when an action is more forceful than might at first seem to be implied by the information inputs to the governing decisions [21:15-16].

The objective of policy makers is to determine the policy or decision rule which control the dynamics of the system so that the system can reach a desired goal (15:30).

System dynamics applies this policy making concept to complex systems. When properly applied, it can help define how decisions are made and what information is used to make decisions. The feedback decision structure becomes extremely useful in determining what actions need to be taken to control the system.

Special Considerations for Systems Dynamics

Like all techniques, there are several issues of special concern in the application of simulation modeling.

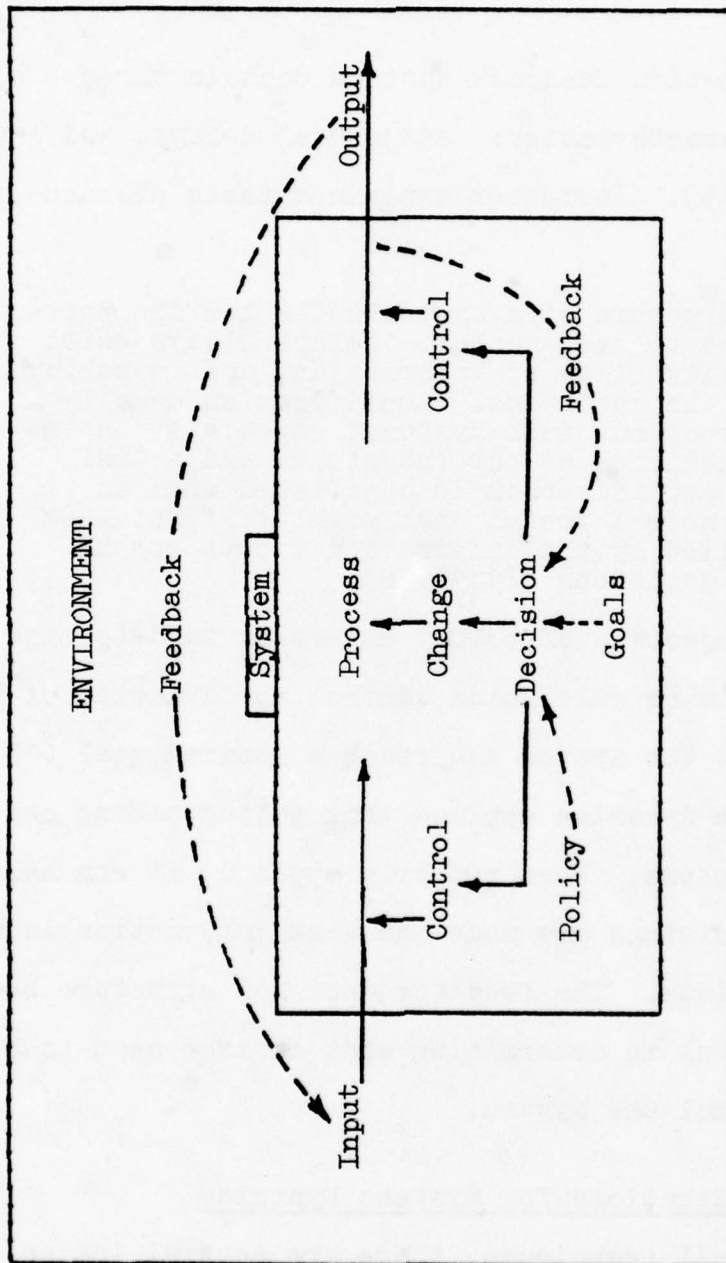


Figure 2-2
Information Feedback System

The modeling process draws a fine line between oversimplification and overdetail. Omission of detail can cause the model to lose its robustness. On the other hand, too much detail can cause a burdensome and wasteful model which disguises the true system behavior (24:112). The model should seek to provide enough detail to be persuasive for its intended purpose. Management should believe that the level of model detail takes account for important issues and problem areas (54:29). Because many system dynamics models pertain to complex management systems, there is a reliance on expert judgment and intuition of management. In the absence of a well-defined body of management theory, or clear-cut measures of performance in the real world, the task of modeling is a challenge (41:19). The results of the model should not be construed as "the" right answer, but rather, a means to understand the general behavior of the system. A final concern is management's attitude. Many managers feel threatened by simulation models, envisioning the models as a replacement for management. This misunderstanding leads to reluctance of managers to use an important tool designed to assist the manager's decision making and policy analysis--not replace him. Simulation simply provides a rapid evaluation of a series of alternatives and variables that cannot be accomplished by man due to the complex and dynamic nature of management situations (21:99).

Applications of System Dynamics

Despite the concerns about simulation, models can provide a forceful and effective tool to management. The system dynamics application of simulation provides a means for management to gain insight into the underlying behavior of their management systems. Modeling also provides a vehicle for systematic evaluation of alternative management policies or the consequences of specific environmental issues which effect the system (53:293). The system logic is built around the goal seeking and growth aspects of complex systems. System dynamics models try to imitate the real-world system in all its faults, so that the manager can see how the overall system operates and reacts to changes in policy without having to apply these changes to the real-world system.

System dynamics models have been applied successfully to diverse areas. Forrester listed several applications of the concept to various real-world situations such as corporate policy, social forces affecting drug addiction, and growth and development of urban areas (24:13).

The value of a model is that it can be used to improve our understanding of the ways in which a system behaves in circumstances where it is not possible (for technical, economic, political or moral reasons) to construct or experiment with a real world system [41:7].

The usefulness of models becomes more evident when applied to research by more than one person. Kadanoff modified Forrester's urban model to study changes to urban communities (24:133). Kadanoff then went on to enlarge the system and produce different results. His explanation for this difference provided a noteworthy insight into the value of models: "He (Forrester) and I have each used the model to explain our different point of view and to put our reasoning in numerical form [37:79]." Therefore, the application of the urban model provided both Kadanoff and Forrester an arena in which their theories could be presented in clear, unambiguous language without going into semantics.

Application to Acquisition Policy

System dynamics modeling has been applied to several areas of the acquisition process. In 1964, Roberts published his study of management of research and development (R&D) projects using system dynamics. His primary contribution was an understanding of the dynamic nature of R&D in both the government and private sector, as well as an invitation for future research in the area of R&D (55). A more specific application to DOD research and development was made by Elder and Nixon. Their research addressed the managerial aspects of R&D conducted within the Aeronautical Systems Division in the Air Force Systems Command (19).

Lawson and Osterhus applied the system dynamics modeling technique to a broader area associated with the DOD acquisition. In their research, they developed a conceptual model of the DOD acquisition process which centered on the interrelationships of six sectors: the Congress, the DOD, the Enemy, Industry, the President and the Populace. From these six sectors they developed a causal loop diagram² of the interaction among these sectors of the weapon systems acquisition process (40). Their research provided a conceptualization of the acquisition process; however, conceptualization is only the first step towards providing a useful management tool. The purpose of this research is to refine Lawson and Osterhus' conceptual effort, incorporate the research of Roberts, Elder and Nixon, develop a mathematical representation of the total system, and, finally, analyze the model to assess the implications of policy changes in the DOD systems acquisition process.

Summary

This chapter contains a review of the literature relevant to the two-fold scope of the research effort: understanding acquisition policy and use of modeling.

²Causal loops identify the relationships between pairs of variables which are linked together in a loop (29:11). A detailed discussion of causal loops is provided in Chapter 3 of this thesis.

The task of modeling complex, dynamic systems is extremely difficult; however, the system dynamics technique is specifically designed to accommodate these situations. Forrester, in the conclusion of the discussion of his world dynamics model states:

Men would never attempt to send a space ship to the moon without first testing the equipment by constructing prototype models and by computer simulation of the anticipated space trajectories. No company would put a new kind of household appliance or electronic computer into production without first making laboratory tests. Such models and laboratory tests do not guarantee against failure, but they do identify many weaknesses which can then be corrected before they cause full-scale disasters.

Our social systems are far more complex and harder to understand than our technological systems. Why, then do we not use the same approach of making models of social systems and conducting laboratory experiments on those models before we try new laws and government programs in real life? The answer is often stated that our knowledge of social systems is insufficient for constructing useful models. But what justification can there be for the apparent assumption that we do not know enough to directly design new social systems by passing laws and starting new social programs? I am suggesting that we do indeed know enough to make useful models of social systems. Conversely, we do not know enough to design the most effective social systems directly without first going through a model-building experimental phase. But I am confident, and substantial supporting evidence is beginning to accumulate, that the proper use of models of social systems can lead to far better systems and to laws and programs that are far more effective than those created in the past [25:126].

Chapter 3

RESEARCH METHODOLOGY

Introduction

The research objectives presented in Chapter 1 provided the general framework for the research effort. This chapter outlines the approach used to complete the research objectives and also provides a condensed description of system dynamics modeling technique.

RESEARCH APPROACH

Procedure

The system dynamics technique provided a logical framework for conducting the research. The study focused on seven specific areas aimed at producing a policy model of the systems acquisition process. These seven areas were:

1. Describing the general system, determining boundaries and basic interrelationships between the major system sectors (subsystems);
2. Developing causal loop diagrams for each system sector in order to show the interaction of system variables;
3. Conversion of the causal loop diagrams into detailed flow diagrams to show how money, material and information move throughout the system and decisions are made to regulate the flows;
4. Developing and verifying mathematical equations which represent the flow diagram concepts. These equations used the DYNAMO simulation language;

5. Validating the model concept to ensure reasonable and logical representation of the real world system structure;

6. Analyzing the system to identify areas sensitive to change and possible system deficiencies; and

7. Recommending changes to the system to improve the structure or information flow and identify areas requiring further study (56:246-247).

A general discussion of these seven steps is provided in the first portion of this chapter. This is followed by a brief application of the system dynamics modeling technology to a simplified model of the acquisition process. This is provided for illustrative purposes and may be skipped by those readers familiar with system dynamics.

Describing the System

The first step in development of the policy model of the systems acquisition process was to describe the system as it related to the specific research problem and objectives (21:21). This descriptive effort began with the review of literature discussed in Chapter 2 and was supplemented with formal classroom study and initial discussions with acquisition managers from the Aeronautical Systems Division and the Air Force Acquisition Logistics Division. Additionally, both Lawson and Osterhus were interviewed regarding their development of the initial conceptual model (40). This initial search for verbal and written descriptions of the

acquisition process served as a starting point for determining the system boundaries. The information gathered from the descriptive model of the system was used to identify and classify important variables required for the more formalized research. Using this information, the conceptual model was described through the use of a system sector diagram, causal loop diagrams, and flow diagrams.

System Sector Diagrams

System sectors provided a useful method for the first analysis of the acquisition process. Sectors divided the system into subsystems which have some degree of unity. This provided a means to group like concepts, processes, and resources together.

The relationships between sectors were defined by networks of materials, information, or money which flow from one sector to another. Forrester stated that capital equipment and human resource flows may be treated implicitly, rather than explicitly within the model (21:139). It was upon this advice that these two factors were removed from the explicit definition of the system.

Causal Loop Diagrams

Causal loop diagrams provided a more detailed analysis of the relationships between system sectors and

also identified the variables and relationships within the system sectors. Through the development of causal loop diagrams, the preliminary system structure was identified in easily understood symbology. This technique facilitated transformation of the system sector diagram and verbal description into a general feedback structure which characterized the behavior of the systems acquisition process (29:12).

Interview Process

The causal loop diagrams, as well as the sector diagram, provided a useful method for displaying ideas about the conceptual model to others for review and discussion. Using these diagrams as the preliminary representation of the model, top executives within the acquisition process were interviewed in order to provide a richer understanding of the decision process and issues. These interviews also provided a means to justify or change variables and interactions described in the initial conceptual model.

The objective of this interview process was to develop additional information about the decision process of policy makers in the acquisition system. Over thirty individuals responsible for the various policy and procedural aspects of the DOD systems acquisition process were

contacted. Among those organizations represented in the research sample were:

- Congressional Budget Office
- House Budget Committee, U.S. Congress
- Office of the Secretary of Defense
- Office of Management and Budget
- Office of Federal Procurement Policy
- Headquarters, United States Air Force
- Air Force Systems Command
- Aeronautical Systems Division
- Air Force Wright Aeronautical Laboratories
- Air Force Acquisition Logistics Division.

A complete list of the individuals who were interviewed is contained in Appendix B.

The interviews were conducted using an interview guide which was designed to provide a consistent, but unstructured arena for discussion (see Appendix A). Questions were designed to prompt discussion about the specific system elements which were the responsibility of the respondent; however, the unstructured approach did not restrain the respondent from offering insights and observations about other areas not within his specific responsibility. The questions were designed to provide specific information about goals and missions, important issues and problem areas, the information network, the decision structure, performance measures, and feedback, delays, and timing of dynamic situations. In addition to specific details about the system, the interviews provided a means to detect bias and gain insight into the general management

philosophies characterized by policy makers within the systems acquisition process.

Flow Diagrams

The interview process provided sufficient knowledge and confirmation about the system to expand the causal loop diagrams into a more structured format called flow diagrams. Flow diagrams are based on the philosophy that systems can be modeled as a series of states or levels which change as the result of varying rates of flow within the system. The decision structure is super-imposed on the rate and level system and serves to regulate the system. The nature of this structure determines the basic behavioral characteristics (53:242).

The flows of money, raw materials, weapon systems, technology, and information are specifically identified in the modeling effort. These flow diagrams provided a basis for developing the equations used in the simulation model.

Equations

The equations developed for the model represent beliefs about the relative relationships between system variables. The development of equations required a conscious analysis of measurement criteria and dimensions applicable to system variables. In many cases, concepts

and surrogate measurement devices were developed in order to represent ideas which had no formal measurement devices within the DOD systems acquisition system. Equations provided the mechanism to translate such statements as "Capability is a function of" The nature of policy modeling does not always allow precise measurement. The focus was to provide qualitative measurement of the system. Forrester stressed the purpose of equations are to represent significant relationships within the system in a manner which captures the overall behavior. Costly and time consuming data collection to develop detailed measurements of the system should not be pursued until a valid initial model is developed and the system is understood (21:141).

Once the equations of the systems acquisition model were formulated, the next step was verification. This ensured that the computer program ran as intended. To verify the model, the DYNAMO equations were compared to the flow diagram to ensure that the equations mathematically reproduce the meaning of the levels and flow rates defined by the flow diagrams.

Model Testing and Validation

The model validation process involved comparison of the model's behavior with the actual system behavior. Due to the iterative nature of model building, validation was an integral part of each step within the research.

The validation approach used a combination of methods recommended by Forrester (21), Coyle (16), and Roberts (55): well known experts in system dynamics applications. The primary objective of model validation was to ensure that model structure adequately represented the system described by the research and provided results consistent with observed system behavior. Borrowing from Coyle, the following definition provided the basis for validation: the process by which we establish sufficient confidence in a model to be prepared to use it for some particular purpose (16:18).

Specific emphasis was placed on content validity to ensure that the system boundaries and system structure and relationships were adequately described. In the earlier stages of the model building, validation consisted of justifying hypotheses and assumptions using common sense, logic, and knowledge gained from the literature search. The interviews also assisted in validating the functional relationships contained in the system equations and specifying the relative magnitude of several essential system parameters.

Detailed statistical study using empirical evidence was not accomplished. As was discussed earlier, once the model has been tested and certain sensitive areas discovered, these highly sensitive areas should be considered for continued model validation.

Analysis of the Model

Analysis of the conceptual and structural models contained in the causal loop diagrams and flow diagrams provided useful insight into the system behavior. This analysis was essential to the internal validation of the system structure and served as a baseline for preliminary determination of sensitive areas and increased understanding of the possible impact of policy changes.

The simulation capability developed in this research provides a valuable tool for management use in policy analysis. Although the operation of the model was beyond the scope of this research, the preliminary analysis which resulted from this research should be used as a basis for system experiments. Two types of experiments are envisioned: tests involving changes in equation parameters, and tests involving changes in the system structure.

AN EXAMPLE OF THE SYSTEM DYNAMICS TECHNIQUE

The following section provides an example of the system dynamics methodology for those readers unfamiliar with the technique. A very simple presentation of the acquisition process showing four sectors and three types of flows is depicted in Figure 3-1. This general model will be used to explain the specific technology required to develop sector diagrams, causal loop diagrams, flow diagrams and DYNAMO equations.

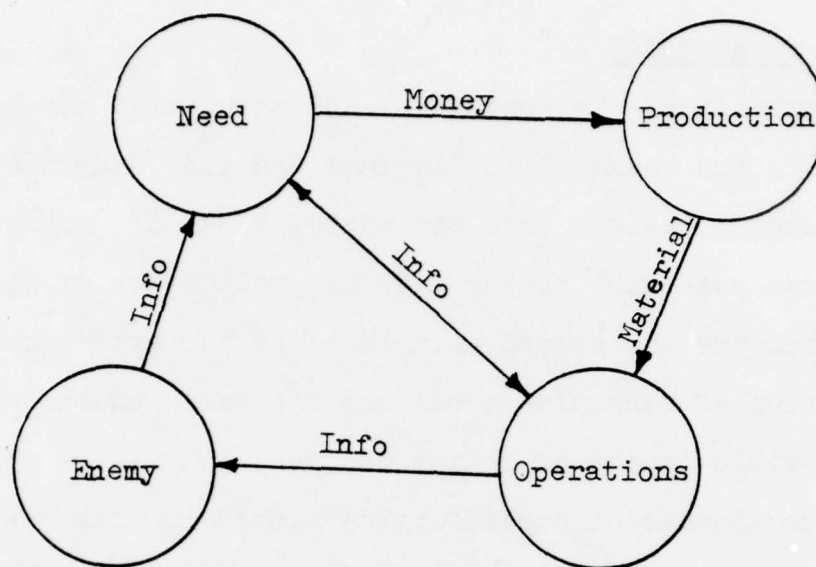


Figure 3-1
System Sector Example

The need sector defines the requirement and provides financing to the production sector. The production sector manufactures weapon systems for deployment in the operations sector. In turn, the operations sector generates additional need to replace weapons that become obsolete or wear out. The operations sector also uses these weapons to create threat which is perceived by the enemy. The U.S. threat to the enemy is countered by enemy weapons production. Subsequently, the counterthreat creates additional requirements. This system typifies the classical "arms race."

Causal Loop Diagrams

The mechanics of drawing causal loop diagrams are not difficult. The procedures for developing causal loop diagrams are to:

1. Identify the variables;
2. Develop causal links¹;
3. Use the causal links to develop causal loops;
4. Join the causal loops into the entire system;
5. Determine the behavior resulting from the causal loop diagrams (40:27).

The basic element of the causal loop diagram is the causal link. This is a pairwise relationship where the cause-effect relationship is depicted by means of an arrow. An example is provided in Figure 3-2.

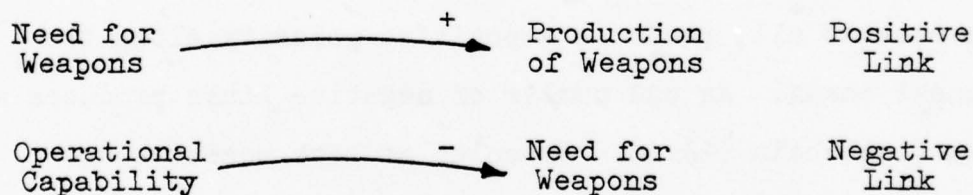


Figure 3-2
Causal Link Example

¹Coyle (16) refers to causal links as influence links, and to causal loop diagrams as "influence diagrams."

The nature of the relationship is noted by the plus (+) or minus (-) sign which indicates a positive or negative change between the two variables. A positive sign shows that, all other things held constant, both variables increase or decrease simultaneously: as the first variable increases, the second increases; likewise, as the first variable decreases, the second variable also decreases. On the other hand, a negative relationship means that the variables move in opposite directions: as the first variable increases, the second variable decreases, and vice versa (29:7).

The sign of the relationship is called polarity. For causal links that contain more than two variables, the polarity is determined by counting the number of negative pairwise relationships. An even number of negative links, or none at all, produces a positive polarity along the causal chain. An odd number of negative links produces a negative chain (29:8). Examples of both positive and negative chains are shown in Figure 3-3.

The next step in developing causal loop diagrams entails grouping the causal links into complete loops. The polarity of the loop is determined using the same procedures as for causal links. The loop polarity is denoted by the sign in parentheses in the center of the loop (29:9-10). Examples of positive and negative loops are shown in Figure 3-4.

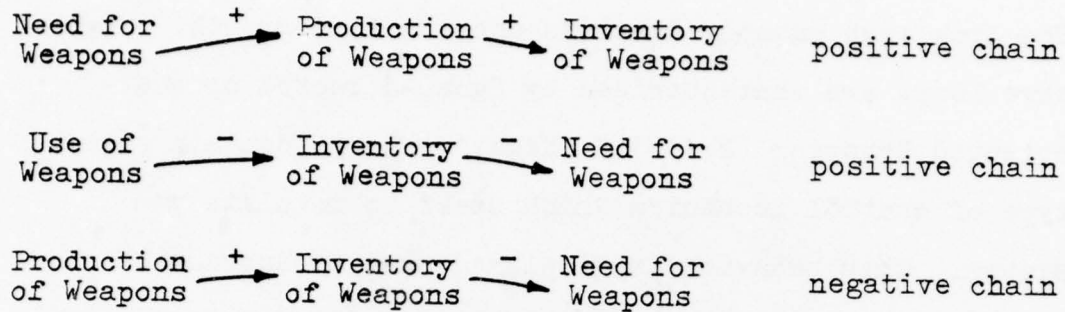


Figure 3-3
Polarity of Causal Chains

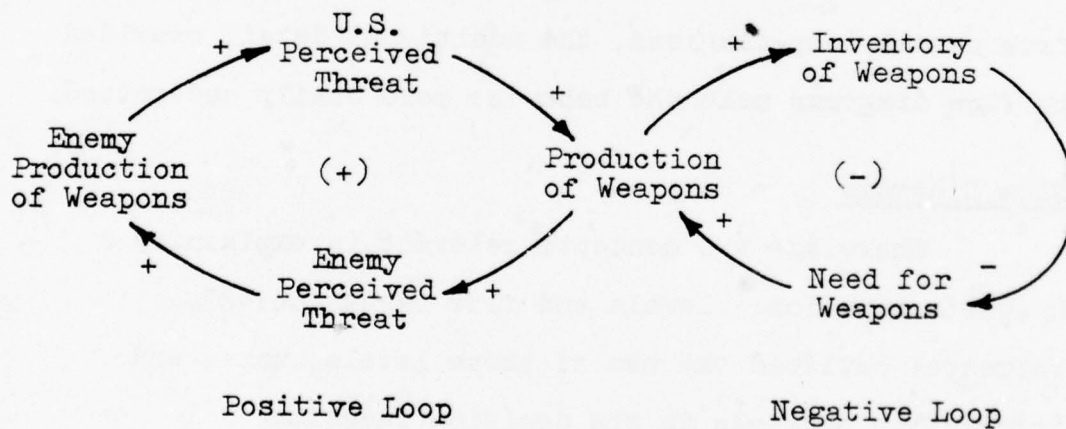


Figure 3-4
Causal Loop Example

Positive loops exhibit uncontrolled growth or decay. The arms race example displays uncontrolled growth. Negative loops are characterized by "goal-directed or goal-oriented behavior [29:37]." Negative loops contain some type of control mechanism which seeks to regulate the system. This behavior is displayed when production of weapons is reduced as needs are satisfied. The basic difference between positive and negative loops is the existence of the control mechanism within the negative feedback loop (29:39).

The overall structure of feedback loops creates the behavior of the system as it moves through time. Although the trends in system behavior can be determined from causal loop diagrams, the additional detail provided by flow diagrams make the behavior more easily understood.

Flow Diagrams

There are two concepts relevant in explaining a system's behavior: levels and flow rates (56:48). Forrester outlined the use of these levels, rates and information channels in the decision function.

The flow channels transport the contents of one level to another, and the flow rates themselves are controlled by the levels. The decision functions are the relationships that describe how the levels control the flow rates. Information channels connect the levels to the decision functions [21:13].

The symbology used in flow diagramming decision functions is depicted in Figure 3-5.

In Figure 3-6, the flow diagramming symbols have been combined into an example. The weapons inventory level is shown as a function of the input rate (production) and a constant output rate (attrition). The actual inventory level is compared to the desired inventory level to determine whether the production rate is sufficient to maintain the desired inventory level.

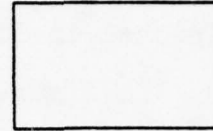
All the variables in the flow diagram must have an operational definition which can be quantified. Without operational definitions, it is impossible to accurately construct the flow diagrams since all terms are measured as amounts in levels and units per unit time period in flow rates.

Equations

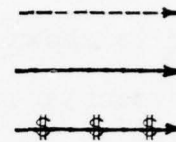
Formulation of equations is the transition step between flow diagramming and simulation. The equations become the basis for a DYNAMO computer model which is used to simulate the systems acquisition process through time.

There are six basic classes of equations used in DYNAMO: level (L), rate (R), auxiliary (A), initial value (N), constant (C), and supplementary (S) equations. Levels, rates, and auxiliary equations all have time dimensions.

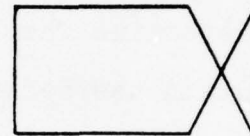
Levels--measurable quantities or accumulations within the system which determine the system state



Flows--the movement of: information
material
money



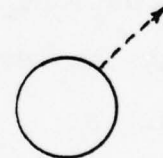
Decision Function (Rate)--policies that control the flows between levels



Source/sink--represents levels outside the system



Auxiliary Variable--provides greater meaning to decision function variables (goals, policies)



Parameter--a constant



Delay--describes the process of time delays

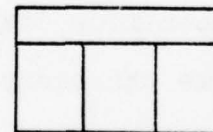


Figure 3-5
Flow Diagramming Symbols (21:82-84)

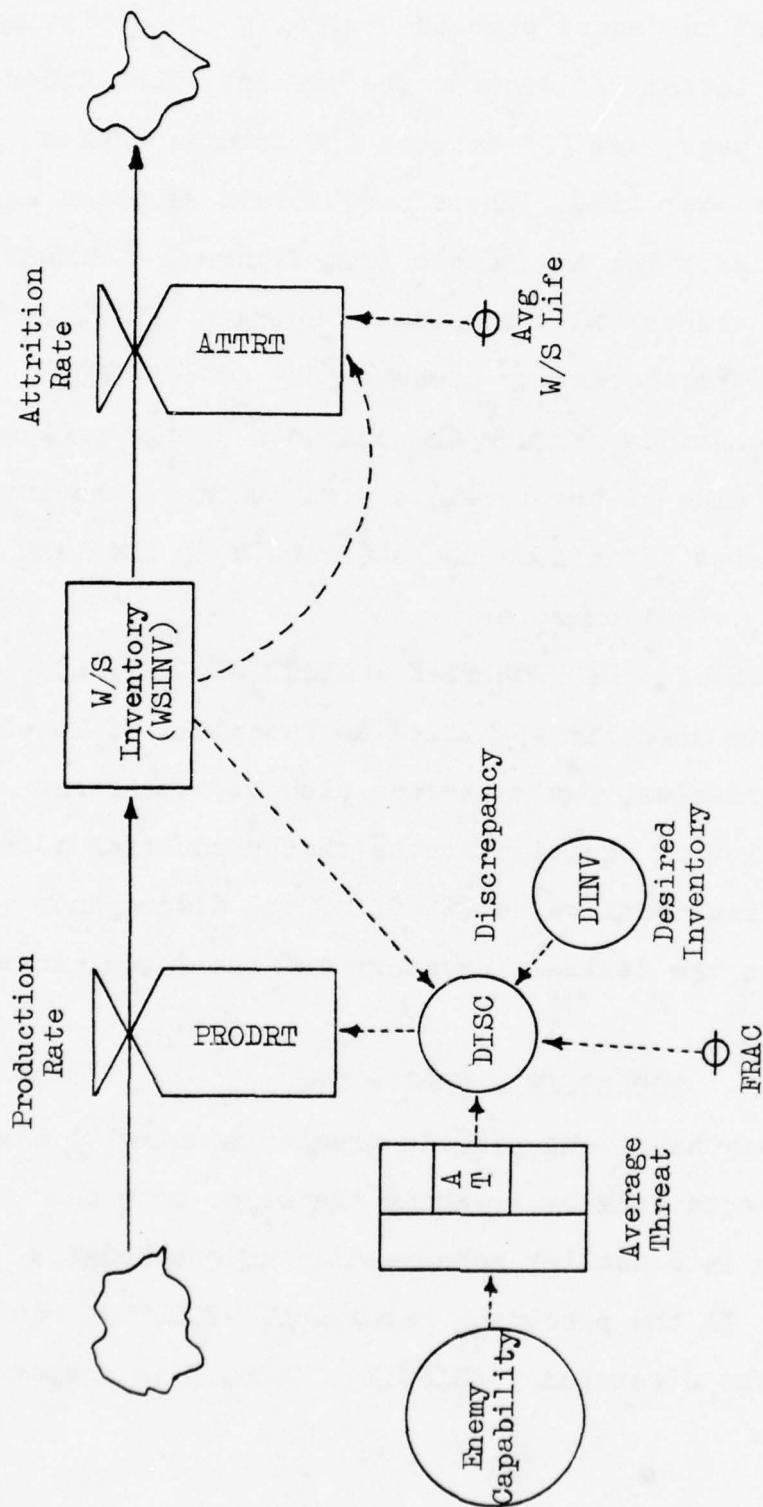


Figure 3-6
A Flow Diagram Example

The notation used to denote time is similar to subscripting variables. The letter "K" denotes the present, the letter "J" denotes the past, and "L" denotes the future. Rates measure movement over time. Therefore, a rate equation uses a double subscript. For an example from Figure 3-6 PRODRT.JK is the variable associated with production rate (PRODRT) over the time interval past to present (JK) (21:73-76).

Level equations measure the contents at the present time (K). The value of the level is a function of the prior level and the rates of inflows and outflows over the last time period (DT). For example:

$$L \quad WSINV.K = WSINV.J + DT(PRODRT.JK + ATTRT.JK) \quad (21:76).$$

Rates are normally specified as functions of levels or auxiliary variables, but rates can also be a constant value. The following equation states that production rate is equal to a fractional value (FRAC) of the discrepancy (DISC.K) between the desired inventory and the actual inventory (21:77-78).

$$R \quad PRODRT.JK = FRAC * DISC.K$$

Auxiliary equations provide greater meaning to the rate and level equations by breaking the major rate and level equations into smaller more readily understandable equation sets. In the preceding paragraph, PRODRT.JK was a function of the discrepancy (DISC.K). DISC.K is computed

by an auxiliary equation that compares the desired and actual inventory:

$$A \quad \text{DISC.K} = \text{DINV} - \text{WSINV.K} \quad (21:78-79).$$

Initial value equations set the initial conditions for all levels. If the initial value of the weapons system inventory was 100 aircraft, the equation would be:

$$N \quad \text{WSINV} = 100 \quad (21:79-80).$$

Constants set the value of a variable for the entire DYNAMO simulation. For example, the desired inventory (DINV) could be set at 120 weapon systems.

$$C \quad \text{DINV} = 120$$

Supplementary equations or SPEC cards are required in DYNAMO to specify instructions required to print and plot model values. They do not influence the computed values that influence the behavior of the system (21:79).

Summary

In summary, the system dynamics methodology provided the basic research approach to develop a dynamic policy model of the acquisition process. This chapter has outlined the basic steps that were taken during the research process and also provided an example of the system dynamics applied to a simple system. Although the steps infer a sequential approach, the nature of the model building was iterative. Many of the steps were reaccomplished as new information became available to enrich the model.

The results of the research follow in the next three chapters. These chapters present the conceptual model, structural model, analysis, recommendations and conclusions relative to the policy model and issues within the systems acquisition process.

Chapter 4

INITIAL MODEL FORMULATION

Introduction

The primary purpose of this chapter is to provide a conceptual model of the systems acquisition process through the use of a system sector diagram, causal loop diagrams, and an explanation of the apparent goals, cause and effect relationships, and key issues relative to each sector. The information contained in the diagrams and discussions results from the literature review and the subsequent interview process. This chapter will focus on providing a general understanding of the concepts which affect the elements within the acquisition process. A more detailed discussion of specific structural elements will be presented in Chapter 5.

The Acquisition System

The acquisition system is characterized by a group of interrelated processes designed to provide weapon systems necessary for DOD missions. The processes are interconnected by the flow of material, money, and most importantly, information. The information network is essential to the system, because it provides the feedback and policy structure which

determine system behavior. Ten system sectors were developed in order to study the systems acquisition process. These first will be discussed as a group to provide an overview of the entire system structure and relationships within the system.

As noted in Chapter 1, the acquisition process is an important element of both national security and economic policy. The goals and objectives of the political system have a significant effect on the relative importance given to DOD missions. The purpose of the political system is to determine the desired mix of policies required to meet military, economic, and political objectives. The decision structure within the political system is influenced by pressures from the various environmental elements, as well as pressures from DOD.

In DOD, the concern of the acquisition system is to identify and justify needs based on the threat perceived from enemy capabilities and political intentions. Needs are identified through continuing mission area analysis. For major systems acquisitions, a formal approval process is required. This process culminates with the Defense Systems Acquisition Review Council approval. As needs are validated, demands for financial resources are forwarded through the Planning, Programming, and Budgeting System. During this process, financial requirements are rank ordered and allocated to the various DOD programs.

The approval of acquisition needs and subsequent funding provide the authority to proceed with research and development. This process transforms the financial and technology inputs into development plans required to produce weapon systems. The product of the research and development effort provides the necessary technical ability required for weapons production. In addition to this input, the production process draws from both the resource and technology bases in order to complete the task of producing weapon systems. As the process continues, weapons are delivered to the operating commands within DOD and also transferred to allied nations.

The U.S. operational forces impact the acquisition process in a number of ways. One of the most significant effects is the impact that weapon system deliveries have on threat reduction. This is due to the increase in capability which reduces U.S. and allied deficiencies. Conversely, as U.S. and allied capabilities increase, the threat to the enemy also increases. In addition to the indirect support to allied nations through increases in U.S. capability, allied defense is affected directly when arms are transferred from U.S. operational forces. In addition to the capability provided from the operational forces, delivery of weapon systems to the commands creates a demand for support.

This demand is eventually supplemented with requirements for new systems necessary to replace the operational force as it ages through time. This final demand serves to complete one system life cycle as a new system need is generated. The concept of the systems acquisition life cycle is represented in the system sector diagram contained in Figure 4-1.

As indicated in the preceeding discussion, the systems acquisition process is typical of multi-looped feedback systems. The goal seeking portion of this system revolves around the identification and subsequent satisfaction of needs. This is accomplished through the development of weapon systems and maintenance of operating forces required to produce desired military capability. The second major loop exhibits the growth aspects of the system, classically named the "arms race". This feedback structure is inclined to perpetuate arms development as the enemy, allied, and U.S. forces seek adequate military protection. Growth is disrupted only as resources, technology, money, or political constraints become factors in the decision process.

The links between the Technology, Weapon System Development, and Production Sectors depict the area of the model which is traditionally associated with the acquisition process. These three sectors contain the central processes

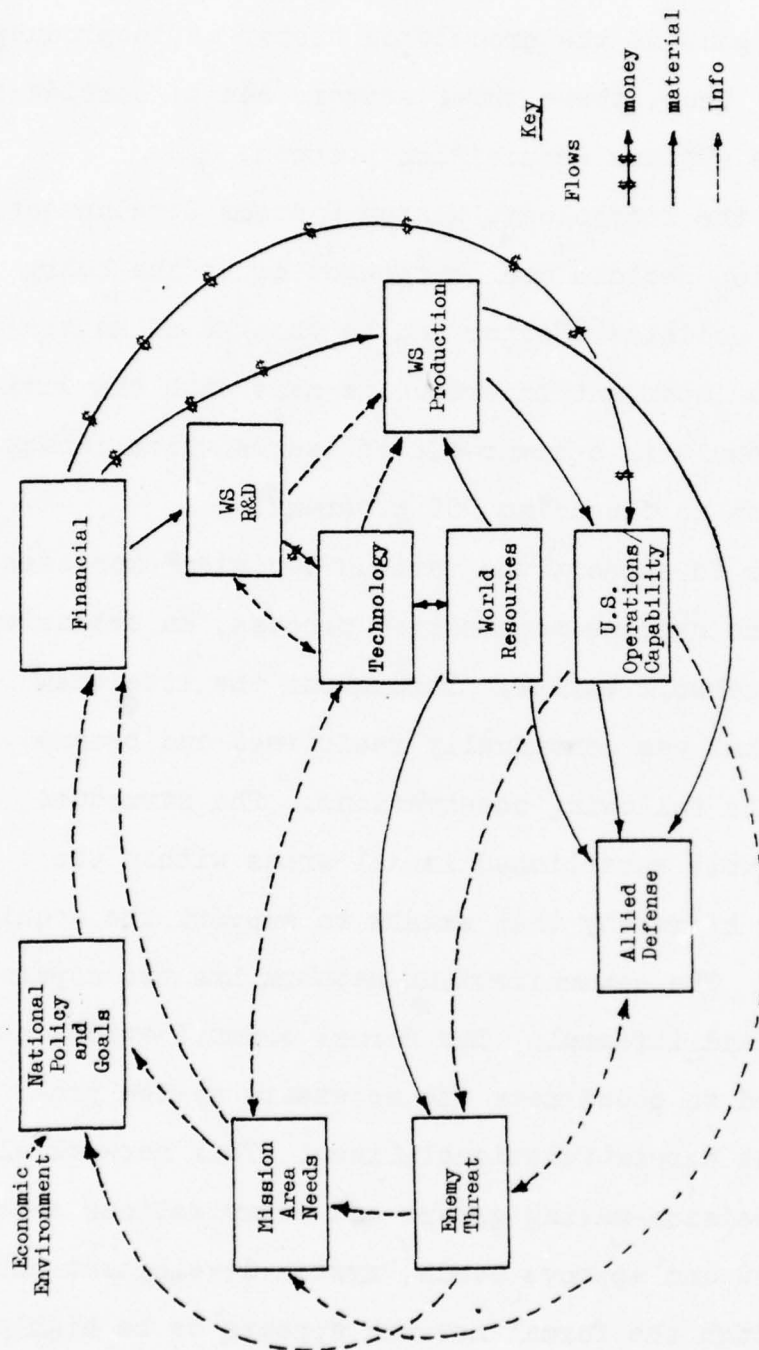


Figure 4-1
Acquisition System

of the system, around which the remainder of the sectors are organized. The goal of the production sector is to produce weapon systems. Thus, these three sectors can be considered the heart of the systems acquisition process.

Just as the Technology, Weapon Systems Development, and the Production Sectors can be thought of as the heart of the system, the Political Sector can be thought of as the brain. Here the important interface is made with the environment. The result is a trade-off of issues which impact the support given to financing DOD programs.

In order to support the various decision processes that occur in the systems acquisition process, an extensive communications network exists. Throughout the interview process this point was continually reaffirmed and became the basis for the following observations. The structure appeared to be well established in all areas within the decision-making hierarchy that exists to support the acquisition process. The communications network has two separate parts: formal and informal. The formal communications network is required to coordinate the necessary system processes which cut across functional lines. This network also includes the decision-making groups and organizations established to review and approve needs, system development and funding. Although the formal network appears to be highly structured, set procedures were established to monitor the

flow of information between individuals and organizations. The informal communications network is far more complex. Informal communications networks provide a means to enrich the information base; but they also increase the total amount of exposure to information by each manager. One manager estimated that he received much more data from the formal network than he required to make decisions; however, the data did not provide the information he believed was necessary to accomplish his job (13). Because of this, he sought out informal information sources.

The decision-making process for systems acquisition is more fully understood when the system's participants, the positions on key issues, and the general behavioral trends can be analyzed. The remainder of this chapter will provide a more extensive discussion of each system sector and the relevant issues and relationships which influence the sector behavior.

Political Sector

The role of politics is essential to understanding the behavior of the systems acquisition process. The decisions and policies made at the national level determine the general policy environment and constraints within DOD, and more specifically, the acquisition process. In essence, this political environment, as presented in Figure 4-2,

serves to balance the pressures and influences from within the DOD with other national goals and objectives. In addition, many of the variables provide the link to other sectors within the model. For example, the perceived threat and intent to use force variables depend upon the Allied and Enemy Sectors, as military and international situations change throughout the world.

The relative pressures which exist in the military, economic, and international arena determine the tone of the political environment. During the interview process, it was noted that these pressures were normally evaluated in terms of dollars. The "power of the purse" appears to be a relatively well understood concept; however, the structure which supports the actual decisions is not as easy to interpret. The pervasiveness of this structure appears to result from an attempt to satisfy many national goals simultaneously. This involves determining the balance between the security and economic goals of the nation and implementing consistent policy to achieve these goals which is a difficult task. A recent analysis of the U.S. power position within the world addressed the failure of the U.S. to recognize the full relationships between political, military, and economic events in order to develop coherent policy to deal with multi-faceted issues in an integrated fashion (62:38).

For military issues, the result of the political tradeoffs made between military, economic, and international demands determines the overall funding and force levels within DOD. In addition, specific decisions are made which impact individual acquisition programs.

In order to deal effectively with military issues, it is necessary to analyze the relationships between the major components of the political system to determine the influence and pressures which result from the political process. Although the precise relationships between the issues and participants within the process were not discussed in this research, the major relationships were confirmed during the interview process. The issues of threat, economic conditions, and the quality of life were found to relate to decision-making within the political environment.

The pressure for DOD programs begins with U.S. deficiencies. These deficiencies are amplified by the threat the U.S. perceives relative to the enemy's capabilities, enemy intent to use force, and the amount of support the U.S. believes the allies will supply in case of war. In this sense, perceived threat is a function of both the size of the deficiency and the political tone of events which occur in the international environment.

Threat is a perception of military capabilities and international environment. The perception is based on the continual evaluation of the trends in military capabilities and intentions. In this respect, the actual threat may not be consistent with what is perceived. The concept is difficult to develop due to both the problems associated with measuring capability and the changing world alliances.

Economic conditions also affect the pressures and influences determining decisions on military issues. As economic conditions such as falling Gross National Product, inflation, and unemployment become concerns within the political environment, demands for non-DOD programs increase.

Borrowing from Forrester (25), military and economic goals can be combined into the concept of the quality of life. This concept represents the relative degree of contentment in the populace. It provides the basis for the guns and butter trade-offs made within the executive and legislative branches of the government. The quality of life has an inverse effect on the demand for DOD programs. As Americans enjoy favorable economic conditions and feel no threat to their security, little popular support is evident for DOD programs. The Vietnam War provides a historical example of this phenomena. Little direct threat was perceived; therefore, many Americans were unwilling to support DOD demands. The electoral process partially ensures consideration of public wishes during the policy

implementation process. The research revealed the defense spending patterns were closely associated with the political pattern. The biggest increases in defense spending occur in the two years prior to the presidential election and the biggest cuts occur in the two years after the election (10).

Public officials, although apparently concerned about the public's desires, also shape their opinions on information and influence resulting from other sources. Specific favoritism and support for selected issues and programs are common within all management structures. Managers have pet projects which become more important than any other management concern. Because the program or issue is important, the manager seeks to highlight the program merits in order to receive support from other areas in the decision-making hierarchy. In the systems acquisition process, weapon systems are advocated by many individuals and alliances. The defense industry, DOD, and the executive and legislative branches all participate in the selling of weapon system programs. Few controversial programs are approved without a coalition of supporters from all levels in the process. Advocacy may result from a desire to keep specific geographic locations or contractors healthy, sincere belief that one program approach is more desirable than another, or unusual pressure to pursue a particular course of action from other participants in the system.

The interview process revealed that the informal communications network serves the advocacy concept well. It is important to know where top decision-makers stand on specific issues and also to establish information sources to provide continuing status on political positions. Most managers believed these sources were essential to their personal data base.

One form of advocacy readily apparent in the acquisition process is lobbying accomplished by the defense industry. In this discussion, the term lobbyist represents both formal and informal pressures by the defense contractors. The pressure results from contacts with industry in formal meetings, as well as informal visits and discussions with defense contractors. Lobbyist pressure intensified as economic conditions required the defense industry to seek new business (36:135).

Another source of influence upon the political decision-makers results from DOD. The services explicitly lobby for support of specific programs. In addition to this explicit influence, the past and current performance of DOD acquisitions also impacts the political support for DOD and specific acquisition programs. Many of the staffs stated that specific technical and cost measures were evaluated in the decision-making process. For example, cost

growth on the B-1 bomber provided one of the reasons for cancellation of the program. In other cases, decision-makers within Congress, OMB, and OSD withheld funds in order to force policy or procedural changes. This activity provides additional influence which affects the DOD environment.

In summary, the political environment which surrounds the acquisition process is important to understand, although it is unwieldy and difficult to anticipate. The decisions made by the people in the executive and legislative branches of government are influenced by three separate forces: popular support measured in terms of the quality of life, specific interest groups and personal advocacy positions, and the influence and performance of DOD. The relative importance of players who participate in the process, as well as their environment, determines the policy positions which affect the acquisition process. To the extent that the system dynamics methodology is concerned with the interrelationships among the components in the system, the political process is both people and program related, where many situational variables appear to affect the policy outcomes.

Need Sector

The demand for defense systems is the basic input to the acquisition process. The Need Sector depicted in

Figure 4-3 provides a model of the DOD process for identifying mission requirements, evaluating alternative means to satisfy the requirements, and reflecting the decisions which result in a force plan. The output of the force plan is the demand for dollars to the Financial Sector in order to meet the requirements for research and development, production and modification of weapon systems, and continued support for operating forces. The Need Sector behavior is goal seeking in that it strives to satisfy specific needs; however, this sector also provides the input to the arms race concept.

Needs are identified by the intelligence community and the operating commands. The process by which deficiencies are identified is called mission area analysis. Mission areas relate to the basic missions assigned to military forces such as strategic attack or force mobility. The objective of mission area analysis is to compare the enemy capabilities with allied and U.S. capabilities to determine valid deficiencies (74:1-2).

There are several key issues that relate to the identification and planning of needs. Specifically, the issues revolve around DOD's ability to assess capabilities in order to determine deficiencies, the process by which alternatives are evaluated to meet deficiencies, and the role of politics in the planning process.

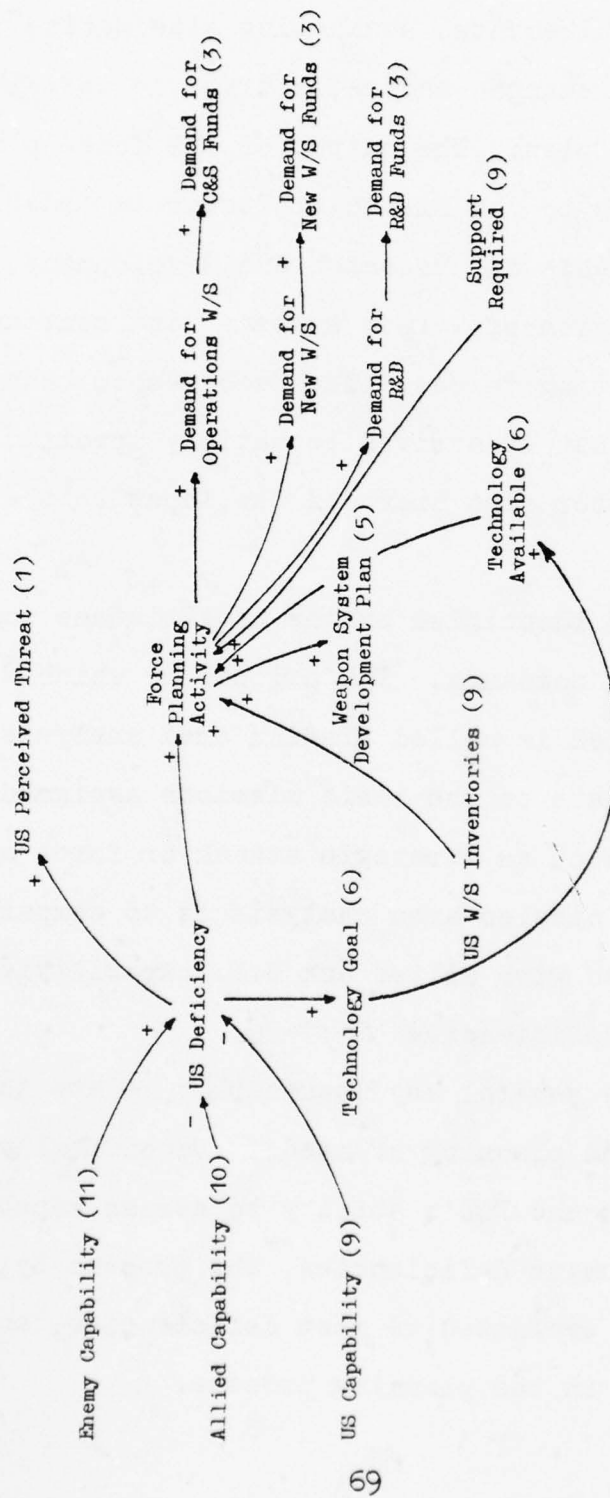


Figure 4-3

Need Sector

The concept of capability can be thought of in terms of a quantity and quality dimension (46:42). Determining the number of forces in DOD, allied, and enemy forces is straight-forward; however, the combination of quantitative and qualitative features of military forces makes the determination of capabilities difficult. Several different agencies have developed capability models, although there is no universally accepted definition or model for assessing capability (5).

One technique developed by the HQ USAF Force Capability Integration Division appears to hold promise. The method requires that individual experts in specific mission areas weigh the importance of subelements within each area and then evaluate the status of existing and planned capability. To facilitate this procedure, a mission area profile is developed in the form of a tree and the results are compared to the known threat for each mission area (Figure 4-4). Deficiencies are noted using a color coding scheme which highlights inadequate and marginal areas of the tree. The final analysis determines the relative importance of the deficiencies within each mission area branch. This results in a comprehensive review of needs which provides a subjective, but logical approach to the difficult concept of capability and deficiency analysis (33:4-7).

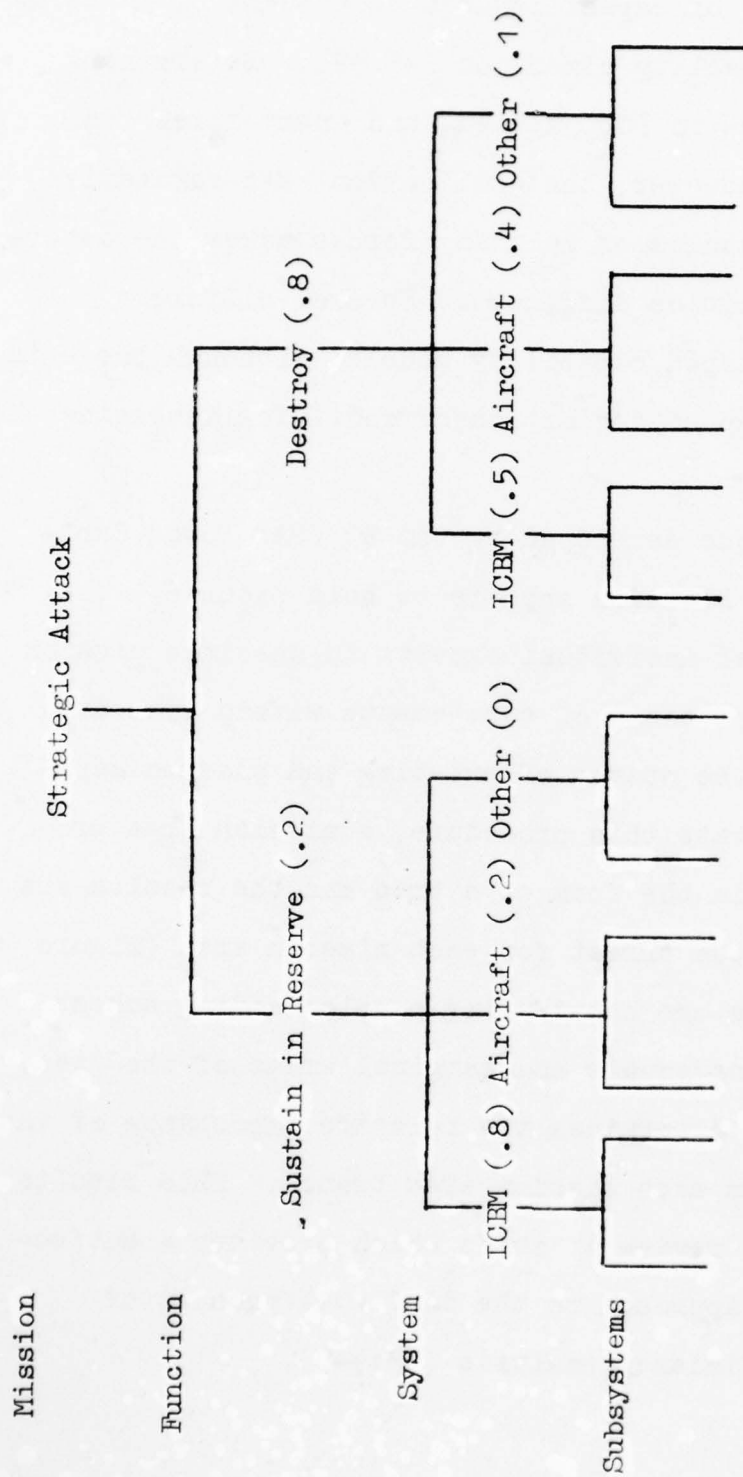


Figure 4-4
Sample Mission Capability Profile

Once deficiencies are identified, development planning defines alternative solutions for reducing the deficiencies. Among the list of alternatives that are considered are: providing additional support for existing forces; modifying current weapons; procuring additional weapons in production or the operational inventory; and developing new systems. Each alternative is evaluated in terms of mission performance, schedule, and costs.

During the interview process, an apparent conflict was noted in the relative importance that decision-makers placed on the performance, schedule, and cost features of needs. In addition to this conflict, the statement of the requirement differed as the need moved through the validation process. At the major command level, great emphasis was placed on the performance requirement. The operating commands focus on specific capabilities, usually relating their requirements to deficiencies in specific hardware terms. The commands are often accused of "gold plating" their requirements by asking for too much performance to satisfy the deficiencies that exist. The rebuttal to this accusation addresses the risk of being caught short at war-time. DOD components argue that the quality dimension of U.S. capability must be maintained by developing technologically advanced systems (46:42). The search for technology to meet requirements within the Air Force is

primarily the responsibility of the Air Force Systems Command (AFSC). AFSC's primary focus is to develop the technological know-how for specific performance needs; however, AFSC also maintains the technology base required to provide answers to needs when they arise (2). Due to the cost of funding research, few projects continue if a sizeable investment is required or if no validated need exists.

Needs requiring a significant investment must be approved by the Defense System Acquisition Review Council (DSARC). These needs are formally documented on a Mission Element Need Statement (MENS). The DSARC consideration of the MENS marks the end of a lengthy coordination process which requires concurrence by many panels and review groups. During the approval process, the primary focus shifts from performance to timing, cost, and other business considerations. The statement of the need also shifts from a specific to general requirement. The corporate structure within HQ USAF and OSD currently requires an estimation of life cycle cost before new acquisitions are approved. This appears to be a difficult task for USAF--where estimates are poor even when specific details are known about the program (71). Although most managers believed cost was still third to performance and time considerations; they also believed cost had increased its importance in the decision-making process within the acquisition process.

The statement of needs in a general format, not specifically tied to hardware, has been of concern to the USAF as the new policy resulting from OMB A-109 was implemented. The policy intended to link requirements to validated needs, evaluate various alternatives, and maintain flexibility in developing systems once the needs were approved (20). Currently, few new systems have been approved. This appears to be due to the long bureaucratic cycle involved to implement the policy rather than a selection of other alternatives in lieu of acquisition. The average time to approve a MENS is approximately eight months (33). This analysis of OMB A-109 implementation was voiced throughout the interviews with managers, as well as in reports discussed in the literature review. The majority of individuals believed the intent of the policy was good; but implementation within the services was poor.

Most needs are identified through the formal decision-making structure established to approve needs included in the force plan. In addition to the structure that exists to generate and evaluate needs, needs are also generated by political advocacy from within DOD as well as from external sources. The entire needs process can be pushed out of routine when programs are changed by individuals who have significant influence over the ultimate decisions to approve or cancel weapon systems acquisitions.

An excellent example of this phenomena was President Carter's order that the B-1 bomber be cancelled in favor of the cruise missile. This caused a reorientation of needs, a restructuring of acquisition programs, and a change in the scheduled time to meet needs. Although the cruise missile did not create a significant problem in the financial arena because funds were transferred from the B-1 program, significant schedule changes were made to meet President Carter's promised date for the cruise missile's initial operational capability.

In summary, the Need Sector attempts to translate deficiencies in military capability into force structure plans and alternative means to meet these plans. In addition, the Need Sector must include political considerations which may alter the initial Force Planning documents. The changes to the planning documents must consider the overall financial constraints within DOD. In the next section, the financial processes designed to match funds to mission plans will be addressed.

Financial Sector

The flow of money is controlled in the Financial Sector. This sector can be described by four specific activities: programming, budgeting, allocation, and expenditure. The demand for financial resources results

from the requirement to implement the force plan described in the previous section. The objective of programming is to link the plans and mission requirements with demands for available dollars. Once dollars are assigned to missions, a budget documents the formal request for funds and the DOD budget is forwarded to Congress for authorization and appropriation (66). Here the most important debate occurs: how much money for DOD; how much money for non-DOD programs (11)? The causal loop diagram in Figure 4-5 portrays the nature of the trade-offs and pressures between these two areas.

Programming and budgeting issues center around the process which rank orders and consolidates financial requirements. This process is accomplished through a series of reviews which aim to match anticipated dollars with mission requirements. Because requirements normally exceed financial resources, some programs are cancelled or delayed, causing revision to the force plan. The decisions to remove or revise programs in the force plan require analysis of the various programming and budgeting alternatives. The analysis seeks to weigh the relative merits and problems associated with all the programs and provide a balanced plan consistent with dollar constraints. Throughout the interview process, managers indicated that few real trade-offs are evaluated either within or among mission areas and

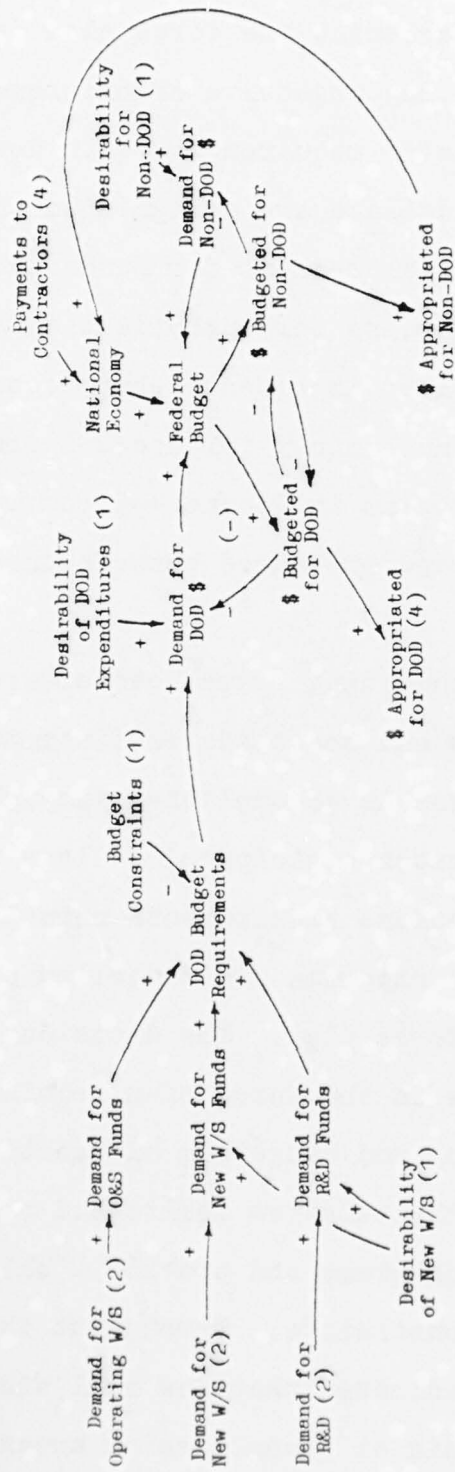


Figure 4-5

Financial Sector--Programming and Budgeting

budget programs. Thus, the goal to provide balanced support is seldom achieved. The reasons provided for the lack of trade-offs within the programming and budgeting cycles involved two specific areas: (1) the extensive information provided to the decision-making body, and (2) the effect of the changing system environment.

Decision-makers in the corporate review structure are provided with extensive data on each program requiring funds. As noted in the introduction of this chapter, one manager received six to eight times more data than he used in decision-making (13). Because of the sheer volume of information provided during the review process, thorough evaluations regarding program trade-offs are difficult. In order to cope with the volume of data, only five to ten percent of the programs are reviewed extensively. These programs relate to the portion of the priority list which may not be funded. In addition to limited alternatives between programs, there appeared to be little resurfacing of initial development alternatives considered for individual programs.

The interview process also revealed that trade-off decisions are difficult due to the changing need environment. The normal procedures call for a lengthy decision cycle extending over approximately two years. This cycle is disrupted when urgent requirements surface. Financial requirements related to these urgent programs must be

force-fit into the budget, leading to last minute decisions with little analysis of the impact on the budget. This last minute restructuring of priorities is further complicated by the influence of program advocacy in the programming and budgeting cycles. Several managers noted the last minute inclusion of "gold watches" or "boss says" requirements into the budget.

Congress is responsible for the debate that determines the overall spending patterns required to meet national objectives (11). The debate becomes difficult when the economic conditions require financial sacrifices by some federal agencies. The results of the debate are specific appropriations based on the budget review. Several managers indicated that the debate often centered around small details relative to specific programs, rather than the macro level trade-offs which should be made in Congress. Although Congress must vote on overall economic goals and other key budget issues prior to the appropriation of dollars, information volume and the dynamic environment create the same problems as discussed for the other decision-making organizations within the acquisition process. Thus, few real trade-offs are made, even at the top levels of the decision-making structure.

Once the decisions are made for the budget, it is executed by expenditures resulting from allocations made to

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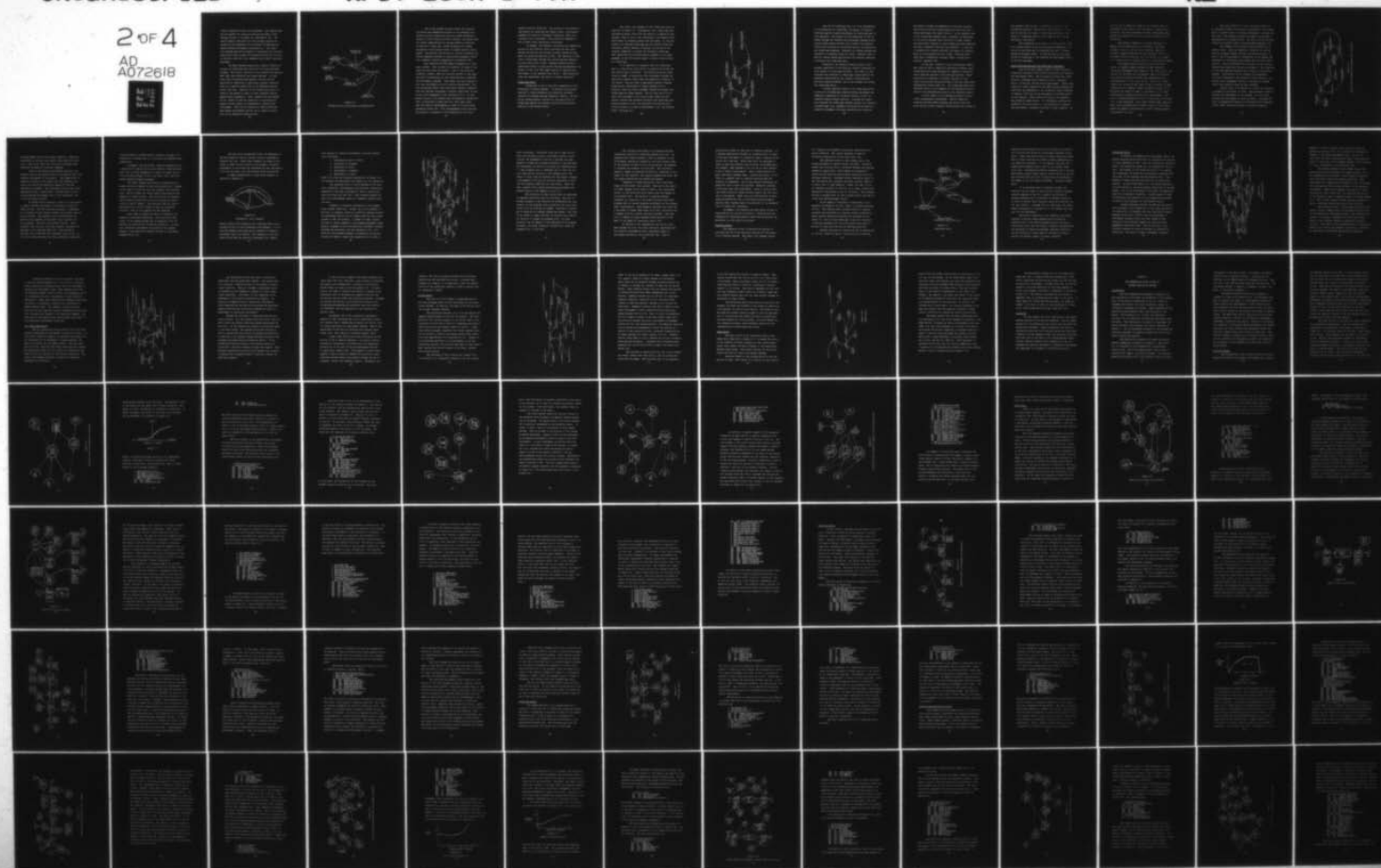
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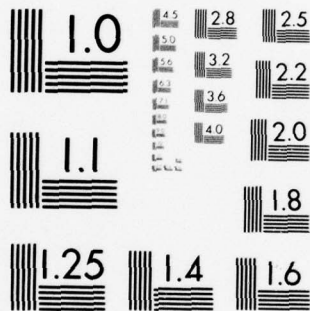
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various components within the government. The expenditures provide payment for goods and services provided to DOD through contract or internal DOD commitments (66). The costs normally associated with the systems acquisition process involve payments for contractual obligations for weapon systems development and production. The causal loop diagram depicted in Figure 4-6 represents the relationships which exist between the appropriated dollars, dollars on contract, and the actual payments which result from work performed.

For major systems acquisition, specific amounts of dollars are associated and controlled for each individual program. This control applies to both research and development (R&D) and production and weapon systems. In other areas such as operating and support, dollars are not specifically identified to individual systems, therefore, there is a greater flexibility in the spending patterns within this area. There is little flexibility within all areas of the system in terms of funds transfers between appropriation categories. Thus, research and development dollars cannot be used for production or operating and support dollars cannot be transferred to research and development. This lack of flexibility creates problems when urgent requirements surface and no funds are available in the designated appropriation.

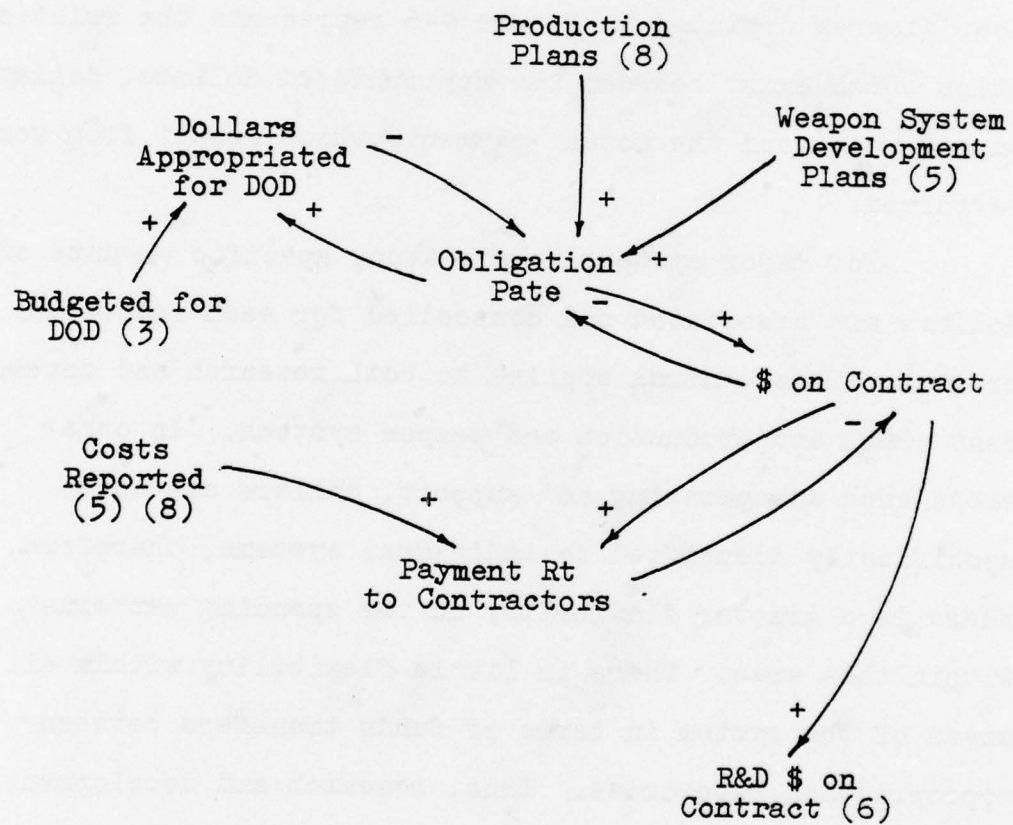


Figure 4-6
Financial Sector—Allocation and Expenditure

One of the primary concepts within the financial allocation and expenditure process is the spending rule. Financial policy legislation does not permit spending in excess of total dollars available; however, the system does not reward organizations for saving financial resources. In addition to this rule, recent pressures for timely obligation of dollars may result in rushed contract development. The quality and the type of contract determine the overall expenses incurred on acquisitions programs; therefore, adequate contract preparation is essential (73).

Most research and development programs use a cost-type contract. This creates the potential for many of the risks involved with cost growth. Some of the costs are avoidable; however, many are directly related to the risks involved in contracting for the uncertainties of research and development programs. Many times, the real reasons for poor cost performance are not correctly interpreted. The cost growth may result from contractual defects, pressures from the business environment, economic conditions, as well as poor cost management by the contractor (30). As cost growth occurs in one research and development or production area, dollars must be made available from other areas. This may require reprogramming of funds if dollars exceed thresholds within DOD. This reprogramming action requires the approval of Congress or DOD depending on the dollar

amounts involved (66:57-58). The problem of cost growth is less severe for operating and support costs. Anticipated payments are easier to determine; therefore, fixed cost contracts can be developed. This allows for expenses to more closely track contractual obligations.

In summary, the financial allocation and expenditure portion of the financial sector provides the last link between the DOD and the national economy through the payments for goods and services by DOD. The character of this link is established through the contracting and financial policies which exist in DOD. Systems acquisition has a significant effect on this process because approximately ten percent of the total DOD budget applies to Research and Development of new systems alone (68:15). When production costs are considered, the effect is further amplified.

Technology Sector

Technology is one of the basic ingredients in the development of weapon systems. It provides the know-how required to develop hardware and industrial processes required for defense systems production (38:42). The DOD policy towards pursuit, protection, and application of technology impacts the economic activities and national security of the United States.

The causal loop diagram for the technology sector is depicted in Figure 4-7. Although the total technology base continually grows, within DOD the behavior is generally goal seeking. This is due to the technology or performance goals established for defense products and processes. As the gap between the existing technology and the desired technology increases, greater amounts of pressure are placed on the research community to provide the necessary technology. This characteristic was particularly apparent in the space programs of the 1960s which sought to provide state-of-the-art technology.

It is important to recognize that the technology goal is a key policy issue which is currently receiving far more debate than in the past. The United States has traditionally sought to achieve military advantages through the qualitative aspects rather than the quantitative aspects of its forces. This has been accomplished primarily through technological superiority of weapon systems (46:42). Recently, there has been a movement towards developing less technologically risky weapons. The A-10 and the F-16 aircraft are acclaimed to be a step in this direction (60). Several studies have presented evidence that producing less complex systems is more cost effective and provides more reliable results in terms of performance, cost, and schedule plans (17:23-29; 61).

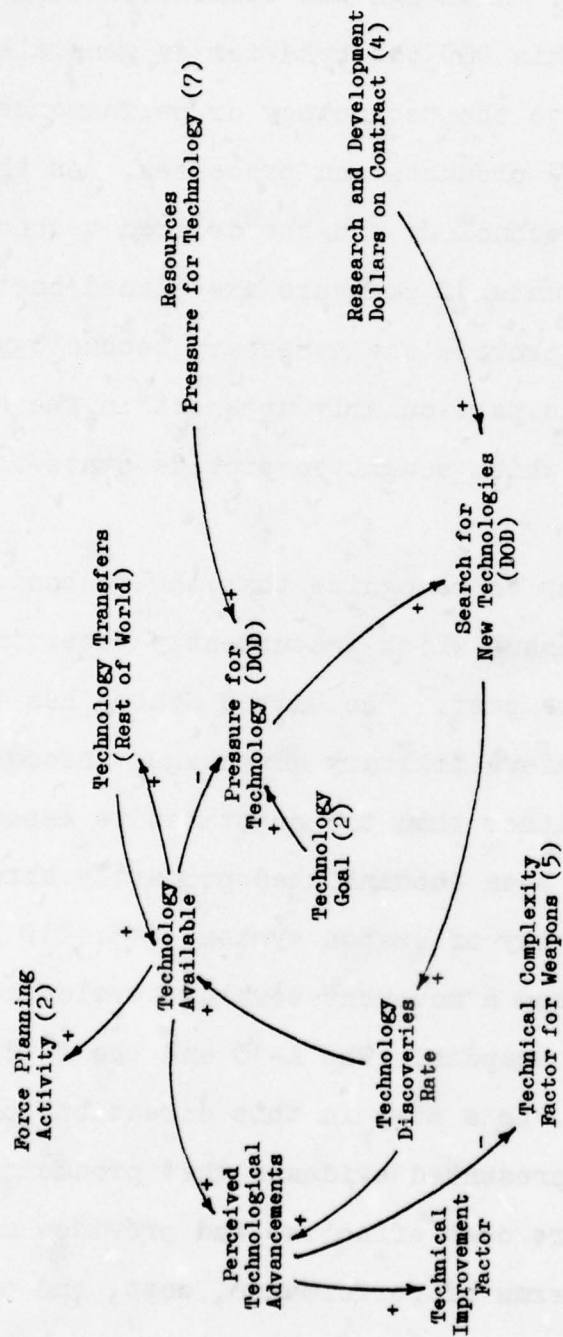


Figure 4-7
Technology Sector

Just as the technology goal is a vital determinant of the pressures for technology, the amount of financial resources applied towards satisfying the technology goal is also important. The search for new technology for DOD is funded through the research and development appropriations. As more funds become available for internal DOD research efforts and contracts in the private sector, the search for new technology heightens. Research for defense systems and processes is conducted along two lines: research aimed at specific weapon system applications and research conducted to maintain the technology base.

Eventually, the research efforts discover technologies applicable to DOD which go towards increasing the total amount of technology available. The result of the discovery and additions to technology relieve much of the pressures established by the original technology goal. This goal seeking feedback loop is the primary loop within the technology sector.

A second important issue in the technology sector is the role of technology transfer between government and commercial industries in the United States, as well as transfers among foreign countries. Although the causal loop displays the technology transfer concept as a positive or growth type loop, transfers are perceived by many as a lopsided arrangement with many underdeveloped countries.

The debate includes the degradation of national security when critical military technologies find their way into Soviet and Warsaw Pact hands (46:42). On the opposite side of the technology transfer issue, transfers of technology to our allies increase their abilities to fight because the qualitative features of their weapons has been enhanced and their industrial base has been improved. In addition to benefits for foreign countries, the export of technologies is a big business for U.S. firms. Limiting trade would have a significant economic effect on many multinational companies (38).

In the past, transfer of new technologies normally went from the DOD to commercial industries; however, more technologies are being developed in commercial industries before they are applied to military applications. These spin-offs are considered a valuable resource for the acquisition process and provide many of the new ideas which subsequently satisfy needs (8). The technology search and discovery cycle is also prompted by the resources scarcity. This will be discussed more fully in the resources sector.

A final concept in the Technology Sector is perceived technological advancement. This is sensed by research and development planners and affects both the goals and the actual technical effectiveness that occurs in

the research, development, and production phases of the acquisition process. The perceived advancement is a function of the rate of change in technology relative to the amount of technology that was initially available in the perception time period.

The estimation of the level of technology required for a weapon system is one of the major determinants in the effort or work required to accomplish the various weapon system development phases. In the next section the application of technology to the research and development efforts in DOD are discussed.

Weapons Systems Research and Development Management

One of the more studied aspects of the DOD systems acquisition process is the activity associated with research and development (R&D). R&D is normally divided into three distinct, although similar phases of work: conceptual effort, validation, and full-scale development. These three phases are linked together by the DSARC decision-making network which was addressed in the literature review contained in Chapter 2 and also in the discussion of the Need Sector in this chapter. After weapons development is complete, the production phase begins. The decisional structure for production is quite similar to the structure for research and development, although the product is more tangible. In

order to avoid repetition, many of the concepts that are contained in this section will also apply to production; therefore, only the differences between research and development and production will follow in the Production Sector discussion.

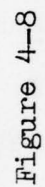
Two general categories of actions and decision-making exist in this portion of the model. The first category focuses on the decision structure required to initiate, approve, and fund R&D and production in the DOD. The second part develops the cause and effect relationship which exists within a program once it is approved and funded.

The formal decision structure which existed to review and approve weapon systems has been addressed continually throughout this research. The DSARC process is captured in the model by four separate phases of activity which are activated by the DSARC and funding decisions characteristics of the actual system. One of the issues which is of concern in DOD today is that the DSARC and PPBS systems are not formally linked; therefore, discontinuity and delay may result if these two processes do not remain synchronized as weapons are developed and produced. This lack of coordination may also be very costly due to stretch-outs or work stoppages. Many recent studies have suggested that closer coordination and formal linkage of these decisional processes be instituted in the DOD systems acquisition process (17; 50).

The basic objective of these decisional points is to determine whether the program is perceived to have enough merit or product value to continue development or production. The causal loop diagram contained in Figure 4-8 provides a representation of product value. The basic concept has been adapted from Robert's model concerning R&D management (55).

Two elements are required in the determination of product value: costs and benefits. Benefits are derived from the progress towards the R&D and production goals, as well as the decision-maker's perceptions of the urgency and importance of the mission requirements and political desirability. Costs are measured by the actual and anticipated expenditures resulting from work performance. The weighting of cost and benefits determine the outcome of the decision process. This process can be compared to programming activities addressed in the Financial Sector; however, the product value assessment relates to one specific program rather than trade-offs made between programs.

Product value is increased as a result of increases in progress or decreases in costs. This provides a means to evaluate the performance of the program. To this basis, desirability and urgency of need are added. Although this idea is conceptually supported by discussions with managers in the formal interview process, the actual weighting



Product Value, Weapons Development and Production

and measurement devices are vague; therefore, completely consistent or rational cost benefit trade-offs are difficult. Even dollar costs are relatively intangible when evaluated in terms of life-cycle expenses.

Prior to any tangible performance measures, the product value is anticipated based on information about the expected performance of the program. This expectation is captured not only in the planned cost and progress variables, but also by the perceived urgency of need and desirability elements. The interviews revealed that early impressions about a system have a lasting effect on the decision-making environment even if new information conflicts with prior beliefs.

As product value increases, there is an inclination to approve further development or production within the DSARC process. The "go" decisions represent a commitment for increases in both planned progress and planned costs in future periods. The progress loop is characterized by growth--more progress, more product value, approval for more progress. The cost loop provides control. Until recently, this loop was very weak; however, affordability appeared to be a growing issue (33). The discussion includes both current R&D and investment costs as well as life cycle costs incurred well after production completion.

Without funding, a program cannot continue, although it is unrealistic to assume that all activities and expenses cease immediately.

Throughout the interviews, logistics managers noted a heavy bias to ignore the out year effects of R&D decisions. This bias is slowly changing as a result of recent initiatives including Design to Cost, Life Cycle Cost, and Integrated Logistics Support programs.

The final elements which affect the perception of product value are urgency of need and desirability. Urgency is the result of both the size and timing of the deficiencies. The B-1 bomber and cruise missile decisions provide examples of these concepts. The need for the Air Launched Cruise Missile became more critical following the cancellation of the B-1 bomber. This resulted from the lack of desirability for the B-1 bomber by many top government officials, such as the Congress and the President.

Once a R&D or production effort is approved, the program is continually monitored. The focal point individual is the Program Manager who is responsible for the majority of tasks related to R&D and production. In addition, extensive requirements are placed on the Program Manager to interface with elements external to the System Program Office (19).

The key control mechanisms within the management of R&D and production efforts include technical performance, schedule and cost. These three elements are highly correlated in terms of their effect on the program. Technical performance is the driver and considered by some individuals to be the only goal, cost and schedule being constraints.

A simple presentation of these three elements is depicted in Figure 4-9.

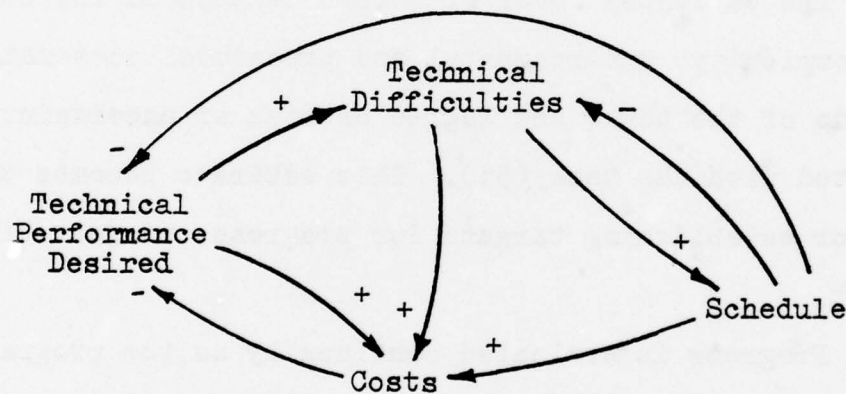


Figure 4-9

Performance, Cost, Schedule

Several studies have supported this cause and effect relationship as well as the discussions with managers (17; 61). Cost and schedule goals may only be reached if technical performance goals are reduced. The remainder of the discussion about R&D and production management will expand

this concept of technical performance, cost and schedule into five areas:

1. Planning the level of effort,
2. Evaluation of progress,
3. Evaluation of costs,
4. Adjustments to schedule,
5. Adjustments to costs.

These five areas are displayed graphically in Figure 4-10 for Research and Development and Figure 4-12 for Production.

The estimated level of effort depends on the technical complexity, environmental and procedural constraints, magnitude of the task, and degree of risk or uncertainty associated with the task (55). This estimate becomes the basis for establishing targets for progress, project time, and cost.

Progress is evaluated continually as the program moves towards completion. In R&D, the actual progress is difficult to measure; therefore, perceived progress becomes the measurement device used to compare what has been accomplished to what was planned. A number of formal reports are used to report progress to the program management staff; however, progress is also evaluated more informally through meetings and discussion with the contractor (19). As a deviation from planned progress or production is noticed, actions are taken to adjust the progress rate in order to

stay on schedule. Deviations occur due to many factors involving estimation errors, unforeseen technical difficulties, and management's ability to provide the right amounts of human and non-human resources to the work task. The adjustment for deviation involves two considerations: (1) what progress rate is required; and (2) what are the cost implications relative to the progress rate? The result of this trade-off between cost and schedule depends on management's bias and the relative importance of both cost and schedule penalties and constraints. There has been a general bias towards maintaining performance and schedule goals at the expense of cost (71).

The evaluation of cost results from the reporting of expenses associated with the work task. The rate of planned progress is the baseline for determining the cost; however, as the progress rate is modified, the costs associated with the work may be changed. Overtime or layoffs may be required or overhead charges may change. The limit on the amount of funds available on contract also effects the decision to change the progress rate. As costs increase, and the amount of time remaining in the program decreases, the funds limitation variable will cause the progress rate to slow down.

The continual monitoring of the program provides information required for adjusting schedule and cost. As progress falls behind schedule, there is pressure to slip the program, causing an increase in the total project time. If the decision is made to slip the milestone, the pressure to increase the schedule is alleviated. The decision to approve a change in milestone decision is a function of the amount of time required, the current progress and costs, and the urgency associated with system development.

Pressures to change contractual cost occurs when funds are used faster than planned. This can be the result of formal changes in the level of effort, cost estimating errors, or the deviations which result from the changes in the progress rate. The decision to approved funding increases is a function of the funds available from other programs and the current progress performance of the program under consideration. Many managers indicated that there was a reluctance to spend "good money after bad", believing that a program could not recover from past problems. This has led to a number of recent systems being cancelled at the DSARC II and DSARC III decisional points (60).

In addition to the impressions that follow a program through its life, the actual decisions concerning cost and technical performance effect subsequent phases of development production, and operational use. This is

particularly evident in the area of technical problems. If a program experiences problems not corrected prior to start of the next development or production phase, technical difficulties will continue. Effort must still be performed in order to meet the technical goals--unless the program goals are changed. Many systems do not live up to their expectations in terms of performance. This is characteristic of many operational systems today. Studies have shown (17; 61) there is a greater risk of technical problems when the schedule is compressed. One of the reasons concurrency was prohibited was to avoid this problem. Technical problems affects more than just performance. Costs to correct problems after production begins severely impact the life cycle cost of the system. These costs are incurred both in modifying the system and also in providing increased support required when a system cannot be maintained at its necessary level of operational readiness.

In summary, the research and development process is characterized by a series of controls. These provide the framework for achieving research objectives and provide the groundwork for the production process.

Resources Sector

The Resources Sector illustrates the process of discovery and use of raw materials required for the production of defense systems. The causal loop diagram (Figure

4-11) depicts five feedback loops which characterize the sector structure. The concept employed is based on Forrester's application in his world model (25).

The resources sector is goal seeking due to the strong influence of limited natural resources. Resources become less available due to increased demands from growing industrial populations. This creates the necessity to search for new resources and increase extraction rates for existing resources. Increased efforts eventually result in new discoveries and increased resources; however, there is a finite limit to this behavior. Today, the limit of the oil reserves available to the U.S. is in sight, barring any substantial discoveries in new oil frontiers. The increased efforts to produce more oil have yielded smaller and smaller volume from existing pumps (62:60).

As the supply of resources is diminished, use is gradually decreased as the full impact of resource shortage is felt. This results from a delayed desire to conserve resources and provisions for resource saving alternatives. These resource saving alternatives are developed as the result of a call for new technology to provide a know-how to develop processes that can use alternate resources or provide for more efficient use of existing resources.

Because resources are limited and may be unavailable to the U.S. except by import, the protection of existing

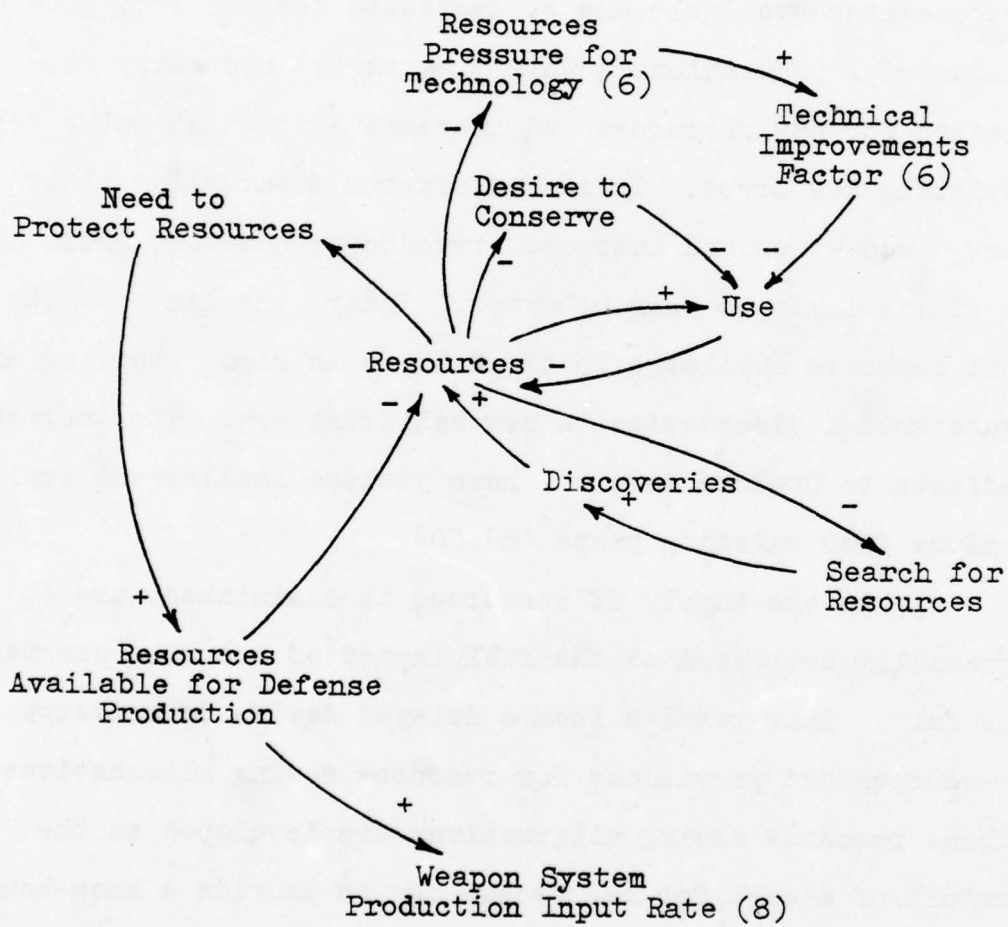


Figure 4-11
Resources Sector

resources and nuturing of political alliances with resource rich countries has become an increasingly important policy issue. Today, the United States is almost completely dependent on other countries for several primary ingredients for our industrial processes. If the supplies were shut off, a significant disruption would occur in our current industrial base. Diplomacy has been the preferred way to develop and maintain supply lines; however, recent events in the Mid East indicate that political alliances are not necessarily the answer to all our resource problems. Alliances change daily.

It is projected that as resources become less available for all users or the political situation degrades resource supplies to the U.S., greater allocations of existing resources will be provided to defense production in order to protect those resources which are available for U.S. use (45:281). Although this is conjecture, the recent events concerning U.S. storage of oil for defense lend support for this hypothesis.

The role of resources in the industrial processes required to produce weapon systems has not played an important role in the decision-making process relative to acquisitions until the last decade. Resource considerations are projected to become increasingly important factors in the U.S. ability to access specific raw materials and to control the economic impact of scarce resources.

Production Sector

As noted in the Research and Development Sector, the system characteristics which exist in production are similar to those addressed for R&D. Only the differences, additional detail, and production issues will be discussed in the section. The purpose of the Production Sector is to combine the technology, raw materials, and financial resources with the output of the research and development effort. This merging of inputs provides the basis for the production process. As noted from Figure 4-12, the process structure is quite similar to the relationships which exist in the R&D phases. One of the differences is the input of significant quantities of material resources. Limited supply of some raw materials can constrain or alter production processes as noted in the discussion of the Resource Sector.

Another difference between the R&D and the production processes is the tangibility of the output production. For production, the assembly and final delivery of weapon systems are much more visible than the achievement of development concepts within the early stages of R&D. Because of this increased tangibility, more top level management review was noted. This is also due to the relative increases in costs as systems are approved for production. The result of senior management attention

appears to create a tighter control network around the production process, but it also increases the information demands on the program management staff. As Fox (26) noted that the public relations and formal briefing process create a large drain on the program manager's time available for actual management of the production task.

The defense industry is the element within this system which actually produces the weapon systems. One of the assumptions for the model is that adequate production facilities exist within the defense industries. Many individuals have supported this assumption (28; 31), noting the over-capacity which currently exists in the peacetime environment. Despite this apparent over-capacity, several concerns have been voiced about the condition and ability of the industrial base to respond quickly to wartime demands (64). This concern requires further analysis; however, it was not considered within the scope of this research.

The conceptual model of the production process does contain several elements which provide greater detail than in the research and development phases. The learning curve concept is included to represent the efficiencies which relate to the learning process as production continues (26:156). The effect of the learning curve is to reduce production flow time as more systems are produced. This must be considered in developing the production schedule.

Production schedules are also different than those in research and development due to the ability to measure actual quantities of systems rather than the achievement of research and development tasks. Many managers noted that the schedule becomes a device used in the programming cycles for adjusting total force requirements to meet financial constraints. Thus, many schedules are lengthened when funds run short, or conversely, schedules are accelerated if urgent threats exist. The schedule, coupled with the abilities of the production process, determines the delivery rate of operational systems to the operating commands. The next section will describe the relationships which exist in the operational environment within DOD.

U.S. Operations Sector

The U.S. operations sector provides one of the basic feedback mechanisms for the systems acquisition process. In this sector, needs for support are generated and capabilities are determined by the employment of weapon systems. The sector is divided into two general parts. The first part deals with the inventory flow within the operational system. The second part deals with the capability information that results from the condition of the various inventories. The causal loop diagram contained in Figure 4-13 provides a framework for discussion.

The inventories within this sector include both operational and non-operational systems. The primary goal is to maintain a desired percent of the systems in operational condition. This goal becomes a measurement device or standard for the commands to compare to actual operational experience. The result of this comparison is an adjustment to the relative pressures for support. In addition to command review of operational performance, other organizations involved with reviewing and approving support plans and new acquisition programs use this as a measurement of operational performance.

Systems are delivered to operations from the production sector. Once the systems reach the field, they are used to meet the planned operating program established for each unit. As the weapons are operated, failures and aging of the fleet occurs. The systems deficiency variable is used to capture both the failure and aging characteristics, in addition to the inherent design problems existing in new equipment delivered from the Production Sector. As the systems deficiencies increase, more systems become non-operational, creating a demand on repair and support. This pressure intensifies as more and more systems are incapable of meeting their assigned mission, creating a request for additional support.

In the Air Force, support costs have increased three times since 1964 (67); therefore, costs related to operating and support are becoming more a concern of top decision-makers within all areas of the DOD system (57). In acquisition, the trend to consider the effects of design on the downstream costs is becoming more apparent from both the beliefs and actions within the acquisition systems. Although the actions are sincere, the difficulties involved with estimating and measuring the pertinent costs and benefits are different. This was described in the discussion on product value.

One manager (42) within acquisition expressed a concern for the increasing age of U.S. operational forces. This results from a lengthening of system life cycles, without timely provisions for replacement systems. Many of the operational forces have far exceeded their planned operational life. This results in increased support costs.

A final issue within this sector discussion is the ability of DOD to measure readiness. As noted in earlier discussions, the percent of systems which are operational provides one of the most often used measurement devices of operational capabilities. This measure is rather shortsighted in that it does not address the abilities to meet sustained wartime mission requirements through the use of equipment, spares, and personnel support. Throughout this

research, the lack of adequate measures for operational capabilities and readiness were noted. Although these concepts are complex, it is important to know the general ability of the operational system in order to provide useful estimates of needs.

Allied Sector

The role of allied defense in supplementing U.S. military strengths draws on both DOD production and operational systems. In addition, the many allies develop their own internal defense industry.

The acquisition system's role in allied support has expanded significantly in the last two decades. The major growth of U.S. military support to our allies began at the conclusion of World War II when U.S. resources were used to restore political and economic stability (62:41). Today, each contract proposal submitted for a major systems acquisition includes a section describing relevant NATO industries and opportunities for co-production (8). Because of the increasing importance of allied defense to the DOD acquisition process, the policies that apply to this sector must consider the careful balance of military, economic, and foreign affairs.

The structure of the allied sector (Figure 4-14) is believed to be a simplified version of the U.S. system.

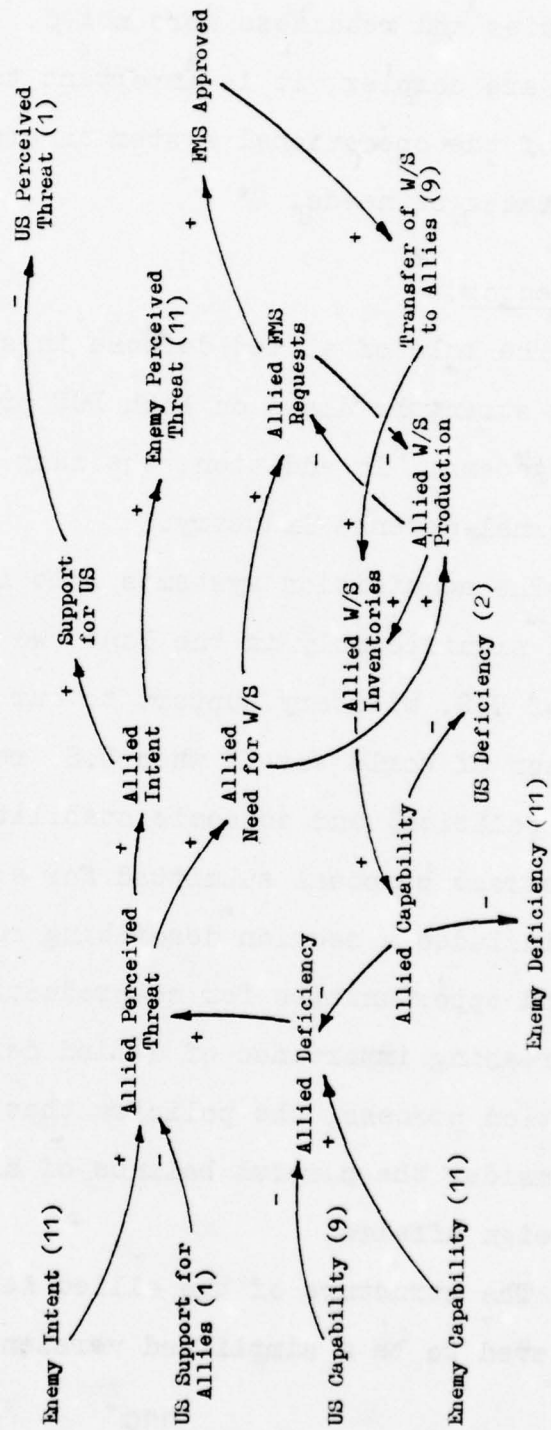


Figure 4-14

Allied Sector

Based on the allied perception of threat, enemy intent, and U.S. support, needs for weapon systems are determined. These needs can be satisfied through in-country production of weapons or through the transfer of arms from the United States. Arms transfers result from the request and approval of Foreign Military Sales (FMS) agreements with allied nations. Normally nations rely on the U.S. for arms when adequate industrial capability is not available within country or when the country's weapons do not satisfy the deficiency. Industrial nations also seek to share or continue development of their capabilities by jointly producing weapons with the U.S. This is called co-production. The F-16 fighter aircraft is the most recent large scale co-production program involving a partnership arrangement between the U.S. and foreign nations. The benefits resulting from co-production arrangements include the sharing of a portion of the acquisition costs, increased standardization of weapon systems and closer economic ties (8). Standardization within NATO is also a separate policy goal currently receiving much attention. Increased use of standard parts enhances U.S. and allied ability to combat the Warsaw Pact threat (64).

The increase in capabilities for U.S. allies lessens the overall threat that both the U.S. and its allies perceive from the enemy. This relieves some of the pressures

on the DOD acquisition process to produce weapons. Many reports stated that the role of the U.S. as a world power is declining. This is placing a strain on U.S. alliances, resulting from doubt of true U.S. intentions to provide support to its allies. This lack of assurance of U.S. support may eventually cause a shift in alliances, impacting the relative threats that the U.S. must counter through the production of arms (62:39).

The motivations which cause shifts in political and economic alliances are related to the concept of quality of life discussed in the Political Sector. The needs for both military and economic security appear to play an important role in the policies that effect political alliances and military support for allied nations. As allied demand for U.S. weapons increases, world diplomacy enters into the considerations of DOD acquisition policy.

Enemy Sector

The final sector in the conceptual model is the Enemy Sector depicted in Figure 4-15. Although this sector is the briefest in detail, omission of the concept represented would remove the major stimulus to the acquisition system—enemy threat. This threat affects the activities within both the U.S. and allied defense systems.

Perceived threat is the driving factor in the production of arms. This threat is a function of the relative

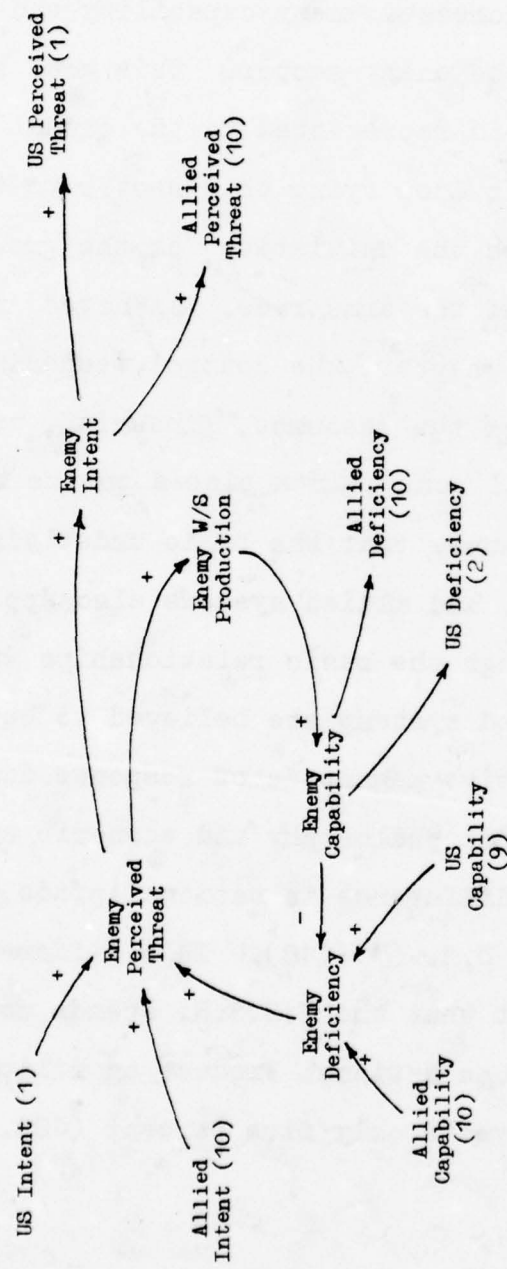


Figure 4-15

Enemy Sector

capabilities and intent factors based on evaluations of the U.S. and allied systems. As the enemy senses threat from these two areas, more weapons are input into production and ultimately provide increased enemy capability and decreased deficiencies within the enemy sector. This goal seeking aspect of the system is represented in the causal loop diagram. The implicit loop tying this sector to the others in the system provides the initiative for the growth behavior characteristic of the arms race. As noted in the introduction to this chapter, the control mechanism on the arms race results from the resource, financial, technological, and political constraints placed on the system.

The model assumes that the basic underlying structure existing in U.S. and allied systems also applies to the enemy system. Although the basic relationships within the enemy, U.S. and allied systems are believed to be similar, the motives and relative magnitude of response differ as a result of the political philosophy and economic systems. Smith noted a large difference in national pride between the U.S.S.R. and the U.S. (58:118). This difference is reflected by the fact that the U.S.S.R. spends more than 11 percent of its Gross National Product on military defense, whereas, the U.S. invests only five percent (10).

The differences between the U.S. and enemy philosophy may lead to slightly different perceptions of the actual intentions and motivations within both the military and political environment. Luttwak noted that the Soviets perceive a military advantage due the sheer numbers of forces and equipment they have in comparison to the United States (44). The concept of perception also plays an important role in interpreting the intent to use force. In times where U.S. intent has been mistaken, the enemy has sought to use force in order to take advantage of a situation, often resulting in military conflicts (39).

Conclusion

In this chapter the first resolution of the weapon systems acquisition process was presented. The key issues and goals of the system and the various sectors within the system were discussed. These discussions were based on information from both the literature review and interviews conducted with key managers within the acquisition process. With this work as the basis of the system dynamics model, the next chapter develops these concepts into the flow diagrams and equations necessary to computerize the system and experiment with changes to structure and policy.

Chapter 5

THE MATHEMATICAL MODEL OF THE DOD SYSTEMS ACQUISITION PROCESS

Introduction

The flow diagrams and mathematical equations for the acquisition policy model are presented in this chapter. Each of the sectors is described by one or a series of diagrams which depict the flows of material, money, or information throughout the system. These diagrams and the equations provide greater detail and structure to the system. The discussion will include the supporting rationale for the equations and functions developed within the model. This discussion is intended to supplement the system concepts, relationships, and issues presented in Chapter 4. The relationships portrayed in the mathematical equations represent the general concepts and beliefs discovered during the research.

The presentation approach will apply the system dynamics symbology introduced in Chapter 3. Each sector will be discussed by flow diagrams and corresponding equation sets. The flow diagram symbols each contain a variable name, symbol, and equation number. The equation numbers are prefixed with a two character alpha code which

corresponds to the sector names. For example, FN denotes financial and PO denotes political. The equations are developed in the DYNAMO simulation language notation. Only the level, rate, and auxiliary equations are developed. For interested readers, a complete, documented listing of the model is contained in Appendix C.

The model developed from the flow diagrams is intended to focus on one mission area. No provisions were made to consider the impact or relationships between different mission area requirements in need identification. This represents the real system process in that few trade-offs are made outside of one mission area except on funding issues. The model does provide visibility of the various funding categories required for research and development, investment, operations and support. Because of the sequential approach to both weapon system development and funding decisions, the three research and development phases and the fiscal funding cycle were explicitly developed. This created a degree of repetition in the model structure which will be avoided in the discussion; however, the repetition was necessary to fully represent the decisional structure which existed.

Political Sector

The informational flows within the political sector provide the basis for the general environment that impacts

the systems acquisition process. In the previous chapter the Political Sector was described as the integration process in which the U.S. balanced the demands for military international, and economic considerations in national policy. This section focuses on four distinct parts of the political system: the impact of international relations, economic issues, general support for DOD, and specific support for DOD acquisitions. The political process which determines the nature of the various pressures is defined by the information structure within the political environment. Because of this, the variables developed in the model relate to the rates and levels within other sectors, providing the important linkage of the DOD systems acquisition process with the political environment.

The first portion of the political sector addresses the international environment. The flow diagram which represents the international environment is depicted in Figure 5-1. Two specific areas are involved: enemy threat and alliances. Both concepts are the result of political intent. Spector (59) developed a method of determining political intent by analysis of trends in the day-to-day relations between two nations. Two general categories were used to classify events: the tone of the event and the intensity of the action. This concept was employed to establish the military intentions of the U.S., allied, and

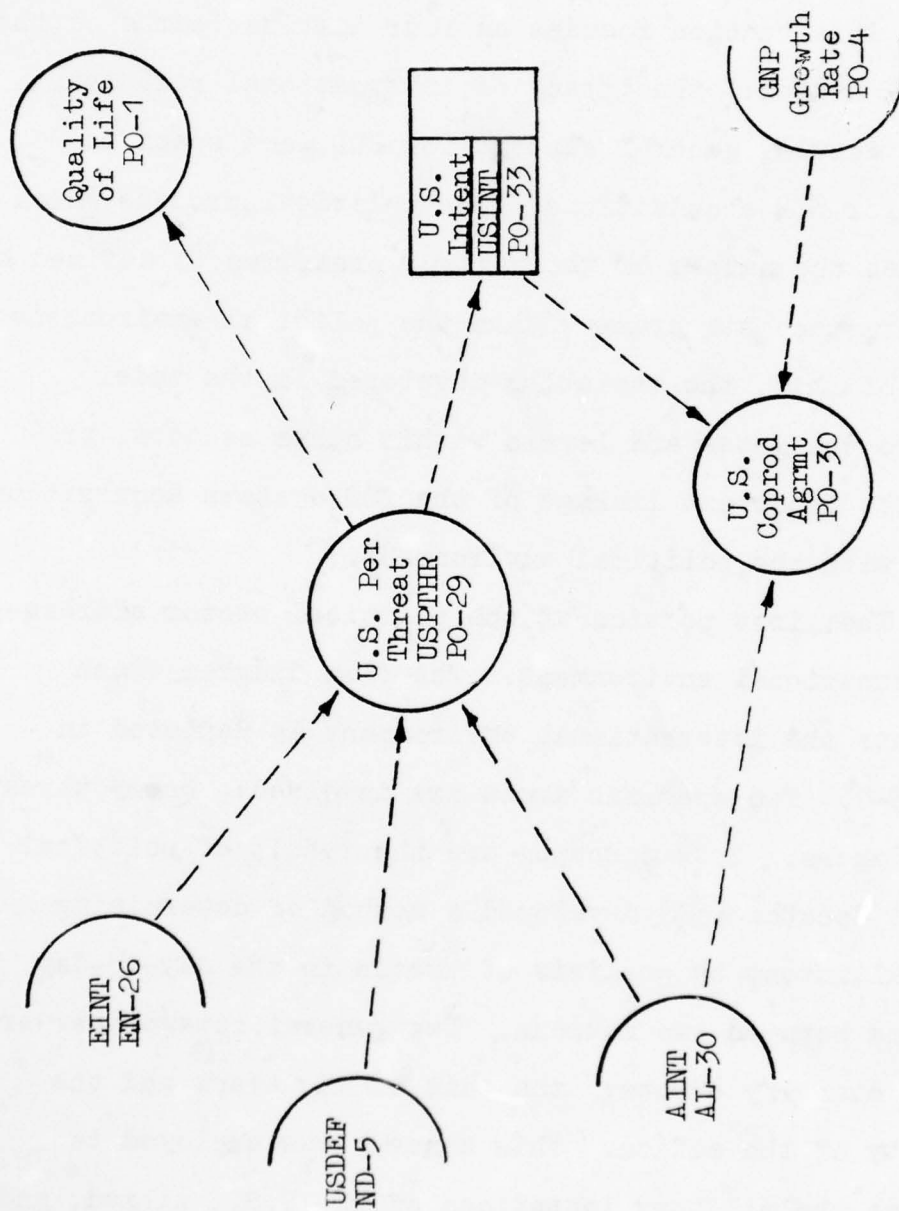


Figure 5-1
Political Sector--International Relations

enemy defense systems within the model. The measure of tone is represented by the threat that a nation perceives. The amount of threat determines the intensity of intentions. As threat increases, the intent to use force also increases. The relationship is illustrated in Figure 5-2.

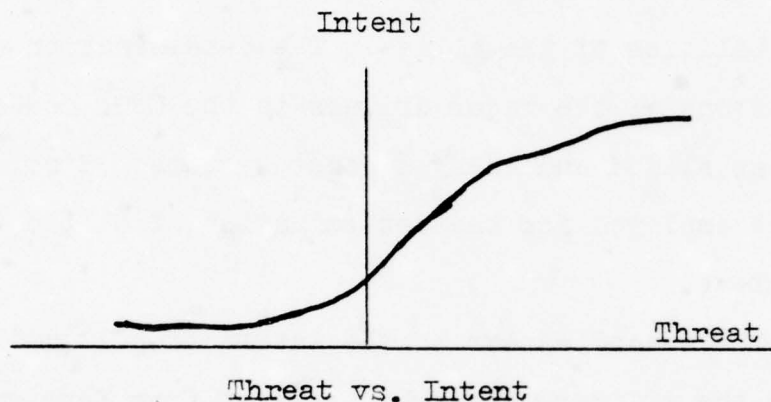


Figure 5-2

Threat is evaluated through time and is not immediately updated. The trend of events determines the actual political intent that a nation perceives. This is represented in the following equations.

```

A  USINT.K=TABHL(USINTT,SPTHR.K,2,.2)
T  USINTT=.0/.0/.0/.1/.8/1.25/1.97/2.35/2.5/2.6
A  SPTHR.K=USURCF.K*SUM(USPTHR.K)/120
A  USDWSL.K=USDESW*TABHL(USDWST,SPTHR.K,2,.2)
T  USDWST=.2/.2/.2/.35/.55/.8/.92/1/1.05/1.1/1.1
NOTE  USINT  US INTENT
NOTE  SPTHR  SMOOTHED PERCEIVED THREAT

```

NOTE USURGF US URGENCY FACTOR
 NOTE USDWSL US DESIRED WEAPON SYSTEMS LEVEL

The other portion of the threat equation concerns the relative differences that exist between U.S. capability and capabilities of the allies. The determination of threat is one of the major drivers in the U.S. needs process, as well as allied and enemy defense systems. Similar concepts are employed for the determination of allied and enemy threat.

The second aspect of the international environment concerns the military ties which result from foreign military sales and co-production. These relationships reduce U.S. and allied deficiencies and also strengthen diplomatic relations. The equations which relate to the international aspects of the political environment are:

A $USPTHR.K(MO) = (EINT.K - AINT.K) * USDEF.K(MO)$
 A $USCOPA.K = CLIP(1.0, AINT.K * SPTHR.K, .8)$
 NOTE USDESW US DESIRABILITY TO BUILD WEAPONS
 NOTE USPTHR US PERCEIVED THREAT
 NOTE EINT ENEMY INTENT
 NOTE AINT ALLIED INTENT
 NOTE USDEF US DEFICIENCY
 NOTE USCOPA US COPRODUCTION AGREEMENT
 NOTE SPTHR SMOOTHED PERCEIVED THREAT

Perceived threat is one of two determinants of the quality of life concept discussed in Chapter 4. The quality of life variable ties the international and economic situations together. The economic system within the political sector is depicted in Figure 5-3. Quality of life is a function of both threat and the general economic conditions in the U.S. In the model, Gross National Product was used to represent the state of the U.S. economy. As economic conditions improve, the quality of life increases. The equations that represent this concept are given below.

```

A  QOL.K=TABHL(QLMT,CNP.K/SPTHR.K,0,5,1)
NOTE  QOL  QUALITY OF LIFE
NOTE  CNP  GROSS NATIONAL PRODUCT
NOTE  SPTH  SMOOTHED PERCEIVED THREAT
L  CNP.K=CNP.J+DT*(GNPCR.JK)
R  GNPCR.KL=.03
A  BUD.K=FBRQMT.K*BRF
NOTE  FBRQMT  FEDERAL BUDGET REQUIREMENTS
NOTE  BUD  FEDERAL BUDGET
A  NDODD.K=BUD.K*PBND.K
A  PBND.K=TABHL(BUDT,NDODD.K,0,1,1)
A  DODD.K=BUD.K*PBDOD.K
A  PBDOD.K=1-PBND.K
NOTE  NDODD  NON-DOD DOLLARS APPROPRIATED
NOTE  PBND  PERCENT BUDGET TO NON-DOD
NOTE  NDODD  NON-DOD DEMAND
NOTE  DODD  DOD DOLLARS APPROPRIATED
NOTE  PBDOD  PERCENT BUDGET TO DOD
A  FBRQMT.K=BRF*(DDMD.K+NDODD.K)
A  DDMD.K=SUM(FYDP1.K)+SUM(FYDP2.K)+SUM(FYDP3.K)
A  NDODD.K=CNP.K*GNPCR.JK*TABHL(NDODT,QOL.K,0,3,3)
T  NDODT=2.5/2.1/1.5/1.2/.86/.67/.42/.21/.15/.11
NOTE  BRF  BUDGET REDUCTION FACTOR
NOTE  DDMD  DOD DEMAND FOR DOLLARS

```

In this model, the interaction of the economy with the systems acquisition process was not defined. The focus

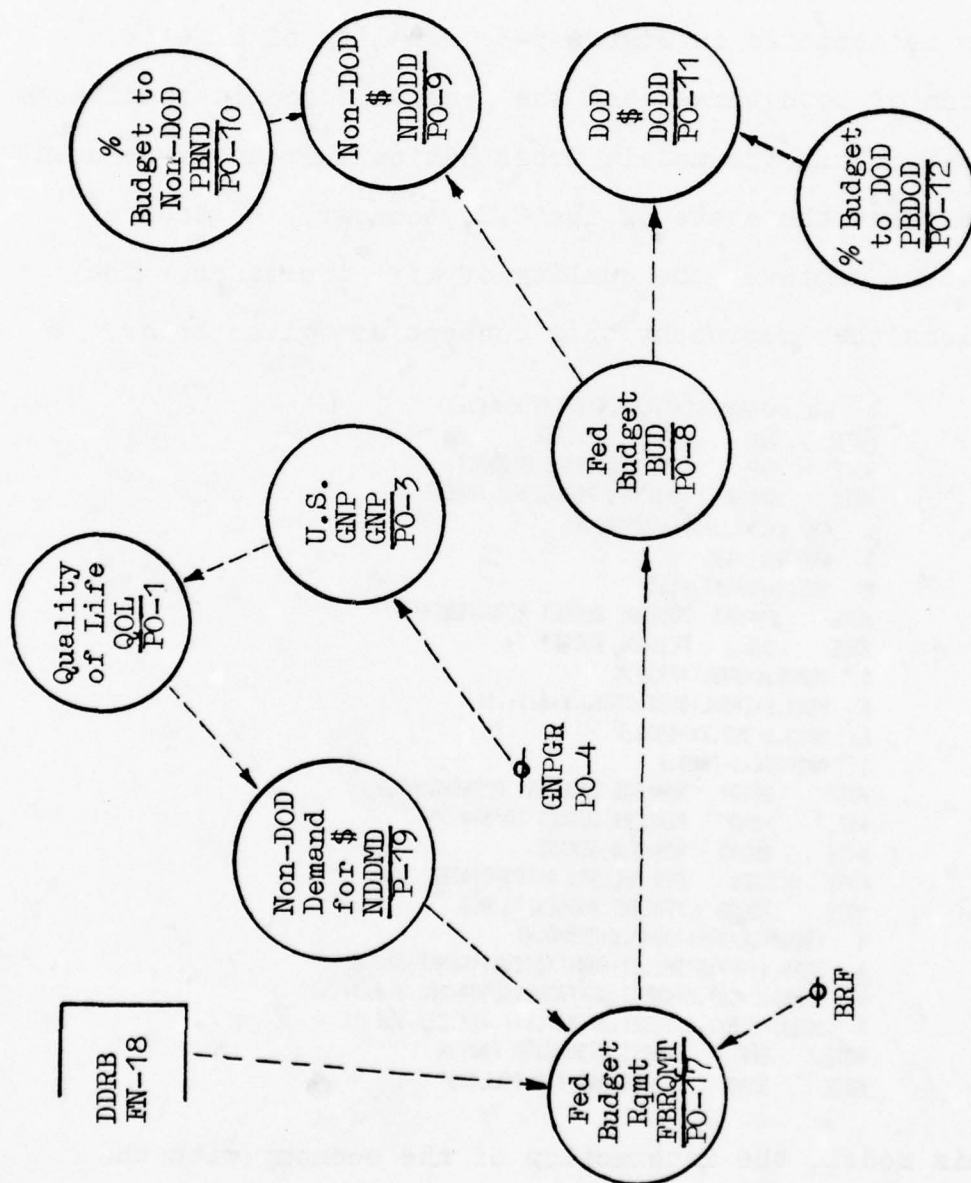


Figure 5-3
Political Sector--Economic Issues

was to show the effect of economic conditions on the acquisition process; not to show the acquisition process' effect on the economy. With this intent, the economic state is assumed to be given in the model.

The third concept within the political sector is the pressures which determine the general funding support for DOD programs. The general mood of the nation towards DOD is partially determined by the perceived threat. If threat is small, there is less desire to build weapon systems. This is related to the quality of life concept discussed previously. Support of DOD is also influenced by the general performance of DOD in terms of cost and performance. If past performance in DOD has been poor, there is a reluctance to support DOD requests for funds. The final consideration which determines the general support for DOD is the specific desires of the top decision-makers within the political system. Presidential and congressional goals for national policy influence the support provided to DOD. The flow diagram which depicts the general support structure for DOD programs is contained in Figure 5-4. The system equations which relate to the diagram are:

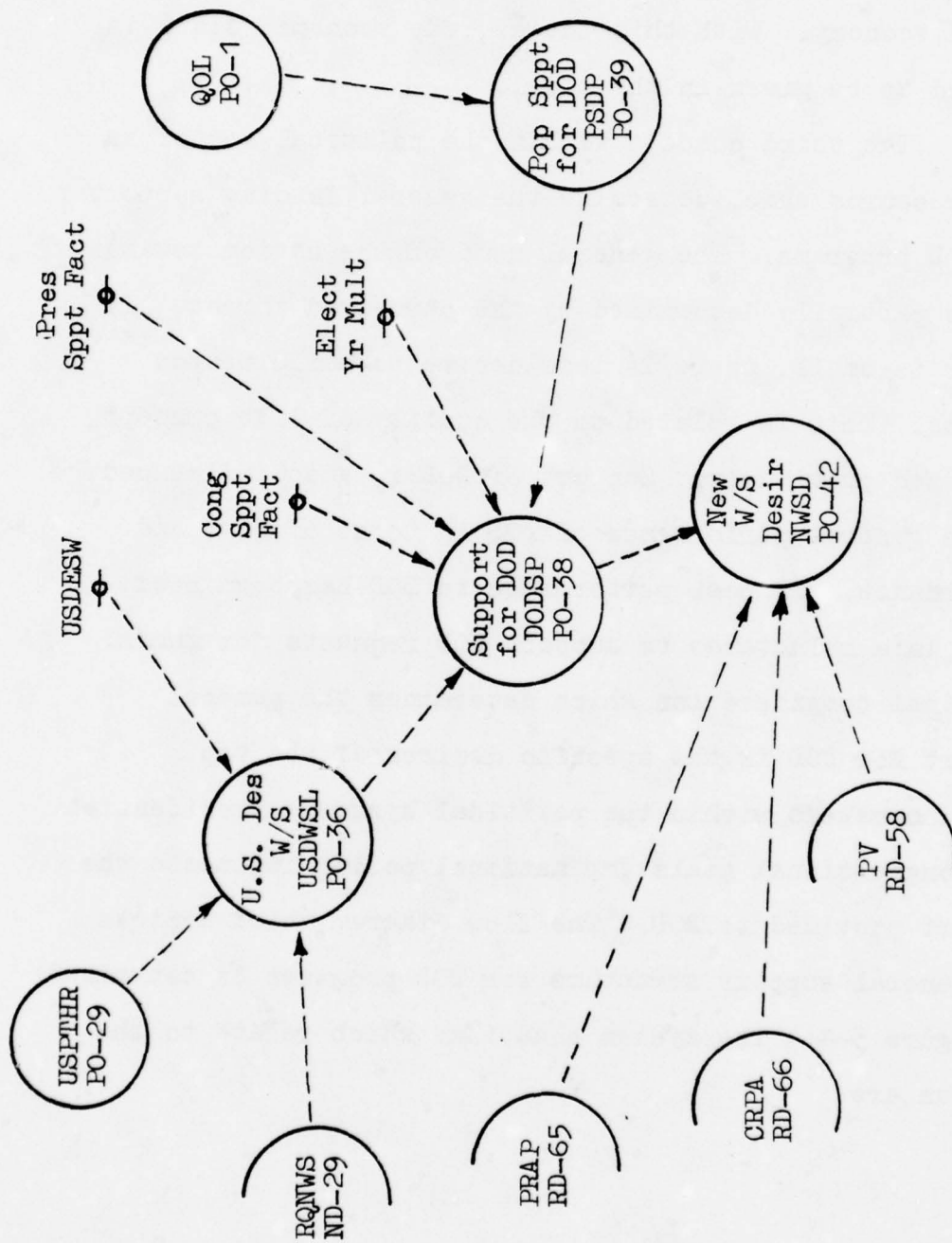


Figure 5-4
Political Sector--General Support for DOD

A $DODSP.K = (PRESSF.K + CONGSF.K + PSDD.K) + USDWSL.K + ELYRM.K$
 A $PSDD.K = TABHL(POPST, QOL.K, 0, 3, .3)$
 T $POPST = 2.0/1.99/1.98/1.87/1.65/1.4/1.05/.85/.83/.8$
 NOTE DODSP SUPPORT FOR DOD IN GENERAL
 NOTE PSDD POPULAR SUPPORT FOR DOD
 NOTE PRESSF PRESIDENTIAL SUPPORT FACTOR
 NOTE CONGSF CONGRESSIONAL SUPPORT FACTOR
 NOTE USDWSL US DESIRED WEAPON SYSTEMS LEVEL
 NOTE ELYRM ELECTION YEAR MULTIPLIER

In addition to general support for DOD programs, pressures are amplified for a specific program by the desires and demands of several factions in the U.S. The relationship of the factors which affect specific program support are area benefits, general DOD support, lobbyist pressure, and desirability of the new weapon system. Lobbyist pressure is measured by the state of the economy using Gross National Product and the technical complexity of the new weapon system. Technical complexity is used to capture the desire on the part of industry to reach or maintain a lead role in the defense industry. As more complex weapon systems are requested, the chance to work on new concepts which may lead to extended DOD business and product spinoffs leads to increased support for DOD programs. The equations which relate this concept to the flow diagram contained in Figure 5-5 are given below.

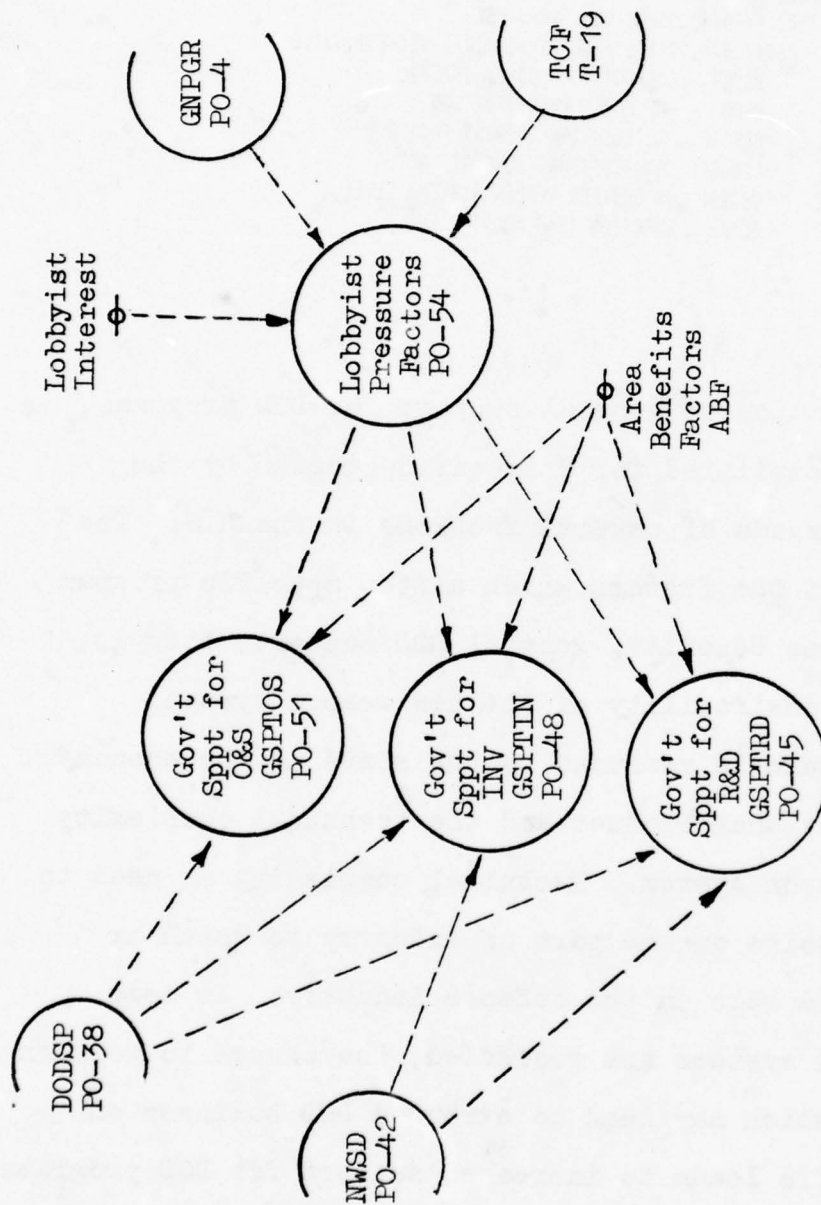


Figure 5-5
Political Sector--Specific Support for DOD Acquisitions


```

A  NWSO.K=TABHL(NWSOT,NWSP.K,0,3,3)+DODSP.K
T  NWSOT=.2/.2/.2/.33/.5/.72/.85/.94/1/1.05
A  NWSP.K=CWSF*CRPA.K+PWSF*PRPA.K
NOTE  NWSO  NEW WEAPON SYSTEMS DESIRABILITY
NOTE  NWSP  NEW WEAPON SYSTEMS PERFORMANCE FACTOR
NOTE  CWSF  COST WEIGHTED SUPPORT FACTOR
NOTE  PWSF  PERFORMANCE WEIGHTED SUPPORT FACTOR
NOTE  CRPA  COST RATIO PLANNED TO ACTUAL
NOTE  PRPA  PERFORMANCE RATIO PLANNED TO ACTUAL
A  GSPTRO.K(1)=TABHL(GSPOT1,NWSO.K,0,1,1)
A  GSPTRO.K(2)=TABHL(GSPOT2,SPTHR.K,0,2,2)
T  GSPTO1=.8/.82/.83/.85/.86/.91/.99/1.1/1.3/1.5/2.0
A  GSPTIN.K(1)=TABHL(GSPOT1,NWSO.K,0,1,1)
A  GSPTIN.K(2)=TABHL(GSPOT2,SPTHR.K,0,2,2)
T  GSPTO2=2.0/1.5/1.3/1.1/.99/.91/.86/.85/.83/.82/.81
A  GSPTOS.K(1)=TABHL(GSPOT1,NWSO.K,0,1,1)
A  GSPTOS.K(2)=TABHL(GSPOT2,SPTHR.K,0,2,2)
NOTE  GSPTRO  GOVERNMENT SUPPORT FOR R&D PROGRAMS
NOTE  GSPTIN  GOVERNMENT SUPPORT FOR INVESTMENT
NOTE  GSPTOS  GOVERNMENT SUPPORT FOR O&S
NOTE  SPTHR  SMOOTHED PERCEIVED THREAT
T  LOBBY=2/1.99/1.9/1.8/1.67/1.5/1.37/1.25/1.16/1.1
A  LPF.K=TABHL(LOBBY,CNPCR.JK/TCF.K,0,2,2)*ABF

```

In summary, the political sector integrates the four factors of international environment, economic conditions, general support for DOD, and specific support for DOD programs into a consolidated plan to promote national goals. Two of these goals are based on providing adequate economic and military security. The threat that is perceived determines the inclination of the political system to recognize and approve mission needs that are developed by the Services. In the next sections, the

process within DOD that identifies and evaluates mission needs that result from the perceived threat is described.

Need Sector

Threat is a function of both intent and capability to employ weapon systems. The need sector consolidates the information that links threat to mission analysis and then to capability. In this sector, the concepts of identifying a deficiency, evaluating alternative methods to meet the deficiency, and planning force structure and budget requirements are defined.

The flow diagram contained in Figure 5-6 portrays the mission area analysis portion of the determination of needs. Three factors influence the system alternatives. The first factor is the deficiency that exists in a given mission area. This process begins with the identification of the total deficiencies which result from a comparison of the relative capabilities of the U.S., its allies, and the enemy. A nation's capability is strongly influenced by the number and quality of current and planned weapon system inventories. The quality factor is a function of the technological advantages; availability of facilities, equipment, and spares support; and the skills and flexibility of the workforce. As the capability comparison occurs for both short-term and long-range planning periods, a portion of

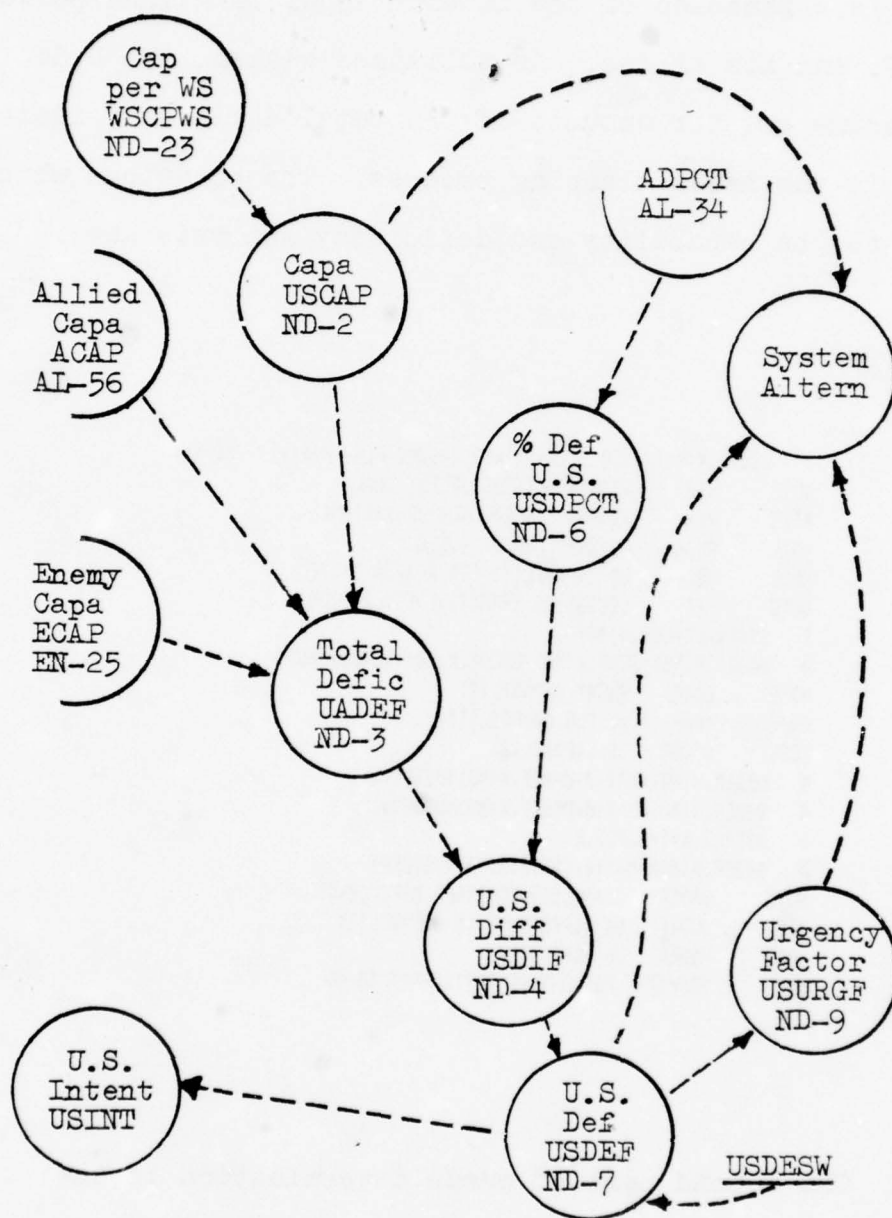


Figure 5-6
Need Sector--Mission Area Analysis

the total deficiency is allocated to the U.S. This allocation is a function of the international relations between the U.S. and its allies. As alliances weaken, the U.S. must assume greater amounts of the total deficiency identified in the needs planning process. The equations which relate to the capability and deficiency analysis are:

```

A  USCAP.K(MO)=(WSO.K+WSN.K+WSP.K+SUMV(PLAN.K(+),1,T(MO))) *
NOTE  WSO  WEAPON SYSTEMS OPERATIONAL
NOTE  WSN  WEAPON SYSTEMS NON-OPERATIONAL
NOTE  PLAN  PLANNED FORCE LEVELS
NOTE  USCPWS  US CAPABILITY PER WEAPON SYSTEM
NOTE  LEF  LOGISTICS EFFECTIVENESS FACTOR
X  USCPWS.K*LEF.K(MO)
A  UADEF.K(MO)=ECAP.K(MO)-USCAP.K(MO)-ACAP.K(MO)
NOTE  ECAP  ENEMY CAPABILITY
NOTE  ACAP  ALLIED CAPABILITY
NOTE  USCAP  US CAPABILITY
A  USDIF.K(MO)=MAX(0,UADEF.K(MO)+USDPCT.K)
A  USDEF.K(MO)=MAX(0,USDIF.K(MO)+USDESW)
A  USDPCT.K=1-ADPCT.K
A  USDEF.K(MO)=MAX(0,USDIF.K(MO)+USDESW)
NOTE  UADEF  US/ALLIED COMBINED DEFICIENCY
NOTE  USDIF  US DIFFERENCE IN CAPABILITY
NOTE  USDEF  US DEFICIENCY
NOTE  USDPCT  PERCENT OF DEFICIENCY TO US

```

The second part of needs determination is the evaluation of urgency relative to each mission requirement. Urgency is a function of the time until the deficiency will exist in the operational forces. If a short-term deficiency

exists, the urgency of the requirement increases. The equations which relate to this concept are given below:

```
A  USURG.K=URGENCY(USDEF.K)
A  USURGF.K=TABLE(EWGT,USURG.K,0,120,10)
NOTE  USURG  US URGENCY--TIME IN MONTHS TIL FIRST DEFICIENCY
```

As deficiencies are identified, the process of evaluating system alternatives to resolve the imbalance in military capabilities begins. The decisional process is influenced by the magnitude, urgency, and the current capability which exists or is expected from procurement or development of additional system hardware. Four general categories are considered within the model. They are: increasing support for existing systems, modifying existing inventories, investing in additional weapons in production or development, and developing new weapon systems.

The evaluation considers the cost, schedule, and performance implications of each alternative. The flow diagram contained in Figure 5-7 represents this process, although the specific decisional variables are not explicitly depicted on the diagram. Each of the alternatives will be discussed as it relates to the decision process. The process involves a cost comparison of feasible alternatives. Alternatives are judged feasible if they meet

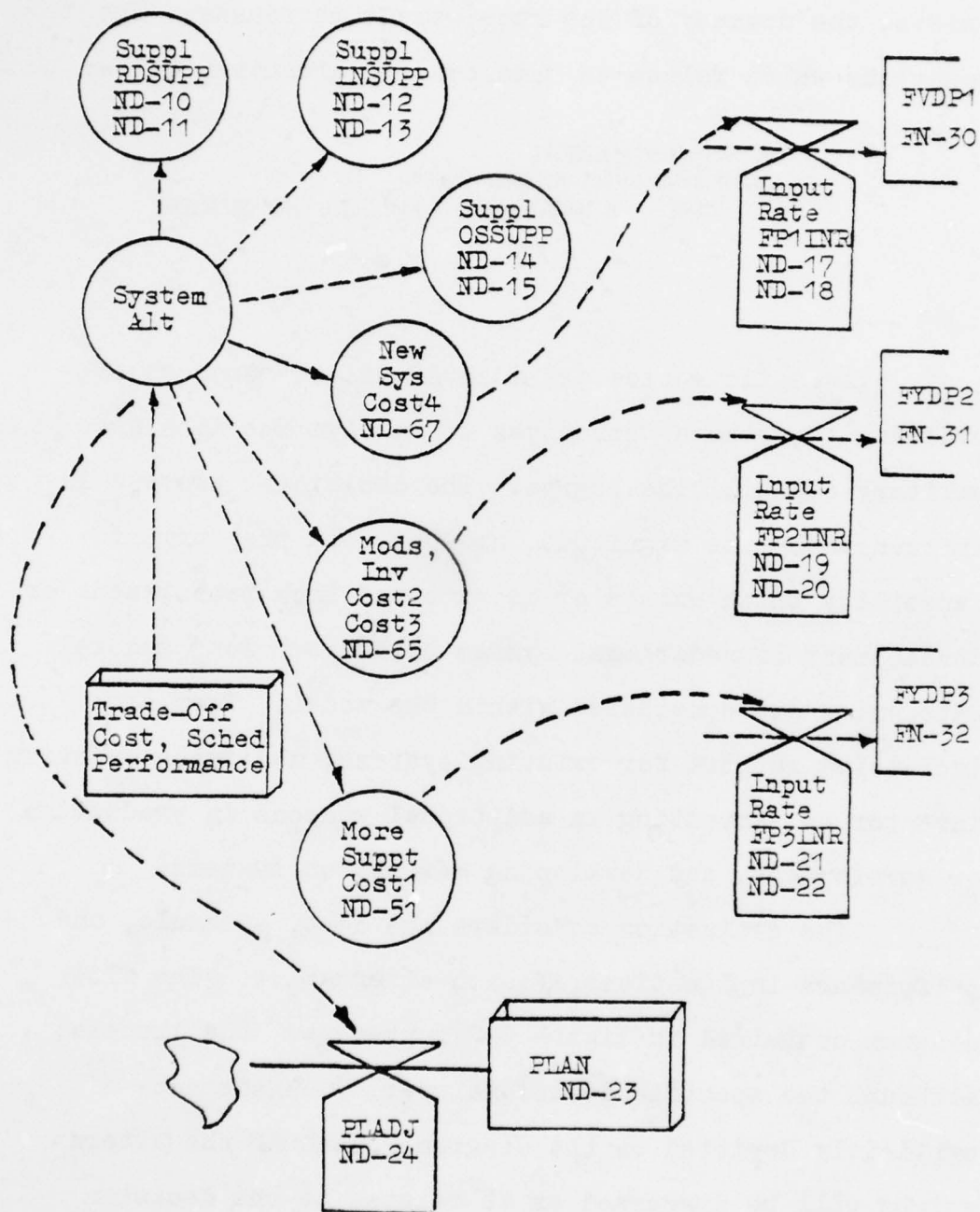


Figure 5-7
Need Sector--Force Planning

the desired performance level required to satisfy the deficiency within the appropriate timeframe. Costs relate to both explicit and implicit values associated with each system alternative. The explicit costs are tangible amounts associated with such elements as procurement or training. The implicit costs are much more difficult to evaluate. They result from the relative values that managers place on specific alternatives regarding risks, pay-off, or personal preference. These implicit costs can be represented by the adjustment of the constants in the model in order to change the relative differences between alternatives.

The alternative to increase support of existing systems considers the costs associated with raising support to achieve the desired capability. Information about current system operations is used as a basis for the decision. As the gap between current and desired capability widens or the capability goal exceeds 100 percent, this alternative becomes infeasible. In the model, the costs of increasing capability grows significantly when capability goals are high or beyond the physical ability of the system. For smaller increases in capability, the support option is considered the least expensive and most responsive means to meet deficiencies. The equations in the model are used to determine the costs associated with increasing the capability from the current rate, expressed as percent of

systems operational to that percent required to satisfy the deficiency. The option is rejected if the number of weapons needed to fill the deficiency exceeds the number available. For example, if 100 operational systems were required and only 75 existed, this alternative would be rejected. The equations which relate to this are:

```

A  VALT1.K=SUM(USDEF.K)/(ORDM*USCPWS.K)
A  SCHF1.K=CLIP(0,1,SCHED1,USURGF.K)
A  COSTF1.K=CLIP(1,0,TFSL.K,COST1.K)
A  COST1.K=TABHL(CST1T,NEWORR.K,8.8,1.,.02)
T  CST1T=10/20/30/60/100/300/550/1200/1E4/1.E6
A  NEWORR.K=MIN(1,DORR.K)
A  DORR.K=(VALT1.K+WSO.K)/(WSO.K+WSN.K)
A  DC1.K=COSTF1.K*SCHF1.K
NOTE  VALT1  VALUE OF ALTERNATIVE 1
NOTE  SCHF1  SCHEDULE FACTOR
NOTE  COSTF1  COST FACTOR
NOTE  COST1  COST OF ALTERNATIVE 1
NOTE  TFSL  TOTAL FORCE SYSTEMS LEVEL
NOTE  NEWOR  NEW OPERATIONAL READY(OR) RATE
NOTE  DORR  DESIRED OR RATE
NOTE  DC1  DECISION CONTROL OPTION #1

```

The modification alternative is reviewed in terms of the expected increase in both performance and life of the weapon system. Both of these effects add to the quality aspect of capability. The performance increase is set as a constant value in the model, however, this can be adjusted

to show the effects of varying degrees of modification. The expected increase in performance is compared to the system deficiency to determine if the alternative is feasible. If the deficiency cannot be satisfied, the alternative is rejected. The cost and schedule factors for modification are computed for feasible solutions. The decision criterion becomes the costs related to the increased capability. This is used to compare to other alternatives. The equations applicable to the modification alternative are given below.

```

A  VALT2.K=USCPWS.K+MODK
A  SCHF2.K=CLIP(0,1,SCHED2,USURGF.K)
A  COSTF1.K=CLIP(1,0,TFSL.K,COST2.K)
A  MODC.K=TABLE(MODFT,MODK,0,100,10)
A  MODF.K=SWITCH(0,MODK,DC2.K)
A  NSYSM.K=MIN((WSO.K+WSN.K),SUM(USDEF.K)/VALT2.K)
A  COST2.K=TABHL(CST2T,NSYSM.K,0,1000,100)*MODC.K
A  DC2.K=COSTF2.K*SCHF2.K
T  CST2T=100/200/300/400/600/840/1100/1500/1640/1700/1750
T  MODFT=1/1/1/1.15/1.35/1.58/1.8/2.05/2.2/2.24
NOTE  VALT2  VALUE OF ALTERNATIVE 2
NOTE  SCHF2  SCHEDULE FACTOR
NOTE  COSTF2  COST FACTOR
NOTE  MODC  MODIFICATION COST FACTOR
NOTE  MODF  MODIFICATION FACTOR
NOTE  NSYSM  NUMBER OF SYSTEMS TO BE MODIFIED
NOTE  COST2  COST OF ALTERNATIVE 2
NOTE  DC2  DECISION CONTROL OPTION #2
NOTE  TFSL  TOTAL FORCE SYSTEMS LEVEL

```

The third alternative evaluates the costs required to produce more of the weapons already in production or in the inventory. Cost associated with this alternative consider the investments cost related to production, including production line preparation. If the production line is still in operation, costs relating to line preparation are minimal. For systems already out of production, costs are higher. The number of years since the last weapon was produced is evaluated to determine this cost. Costs and schedule factors are computed for the desired number of weapons needed to fill the deficiency, and these are compared to the other alternatives. The equations to find the cost of buying more weapon systems are given below.

```

A  SCHF3.K=CLIP(0,1,SCHED3,USURGF.K)
A  COSTF3.K=CLIP(1,0,TFSL.K,COST3.K)
A  VALT3.K=NEWCAP.K
A  NEWCAP.K=PPV3.K
A  DNOWS.K(M0)=USDEF.K(M0)/VALT3.K
A  D3.K=SCHF3.K*COSTF3.K
A  COST3.K=SUM(DNOWS.K)*USCOST.K*AGEM.K
A  AGEM.K=TABLE(AGFT,PLAGE.K,0,120,12)
T  AGFT=1/1/1.1/1.3/1.6/1.8/1.99/2.1/2.18/2.22/2.25
NOTE  SCHF3  SCHEDULE FACTOR
NOTE  COSTF3  COST FACTOR
NOTE  VALT3  VALUE OF ALTERNATIVE 3
NOTE  NEWCAP  CAPABILITY OF NEW WEAPON SYSTEM PRODUCED
NOTE  DNOWS  DESIRED NUMBER OF OLD WEAPON SYSTEMS
NOTE  PPV3  PERCEIVED PRODUCT VALUE FROM PRODUCTION
NOTE  COST3  COST OF ALTERNATIVE 3
NOTE  USCOST  COST OF US WEAPON SYSTEM
NOTE  AGEM  PRODUCTION LINE AGE MULTIPLIER
NOTE  PLAGE  PRODUCTION LINE AGE

```


Finally, the new weapon system alternative considers those costs associated with developing and producing a totally new weapon system. The expected cost of this alternative includes many costs not applicable to the other alternatives. Therefore, the relative costs is considered to be higher to represent research and development expenses. Current policy indicates this alternative should be selected only when no other feasible alternative exists (33). In the research effort, it was noted that this is not always the case. This indicates that management normally places a low implicit cost on alternatives that lead to pursuit of new weapon systems and that the benefits are assumed to be large. The equations which determine the expected costs are given below.

```

A  SCHF4.K=CLIP(0,1,SCHED4,USURC.K)
A  COSTF4.K=CLIP(1,0,TFSL.K,COST4.K)
A  VALT4.K=100
A  DNNWS.K(M0)=USDEF.K(M0)/VALT4.K
A  D4.K=SCHF4.K+COSTF4.K
A  COST4.K=SUM(DNNWS.K)*PC1.K
NOTE  SCHF4  SCHEDULE FACTOR
NOTE  COSTF4  COST FACTOR
NOTE  VALT4  VALUE OF ALTERNATIVE 4
NOTE  DNNWS  DESIRED NUMBER OF NEW WEAPON SYSTEMS
NOTE  COST4  COST OF ALTERNATIVE 4
NOTE  PC1    PERCEIVED COST OF NEW WEAPON SYSTEM
NOTE  TFSL   TOTAL FORCE SYSTEMS LEVEL

```

Once the cost, schedule, and performance factors for each alternative are weighed, the alternative(s) required to meet the deficiency are selected. The decision criterion is least cost. Schedule is considered in the force planning part of needs determination. If urgent requirements are identified, supplemental funding requests may be required in order to counter the deficiency more rapidly than if the normal planning cycle were used. The requests for supplemental funds can be noted from the flow diagram contained in Figure 5-7. Other alternatives that are selected become part of the force plan. This plan contains the number of forces and funding amounts required for plan implementation. Inputs to the plan are made in the annual planning cycle. The equations which relate to the force plan are given below.

```

A  TFSL.K=SUM(FYDP3.K)/USCOST.K
R  FP1INR.KL(1)=SWITCH(0,CNRD.K,DC4.K)
R  FP1INR.KL(2)=FYDPRDC
R  RP1INR.KL(2)=FYDPC+RDC
R  FP2INR.KL(1)=SWITCH(0,COST4.K,WSD3.K)
R  FP2INR.KL(2)=SWITCH(0,COST3.K,DC3.K)
R  FP3INR.KL(1)=NWSP.K+COST.K
R  FP3INR.KL(2)=FYDP3.K(2)+OSC+COST1.K+COST2.K
NOTE  TFSL  TOTAL FORCE SYSTEMS LEVEL
NOTE  FP-INR  DOLLAR REQUEST INPUT TO FYDP
NOTE  COST-  COST OF ALTERNATIVE #-

```

```

NOTE    FYDP3    FIVE YEAR DEFENSE PLAN O&S REQUEST
A    RDSUPP.K(1)=SWITCH(0,RSUP1.K,RSUPAF.K(1))
A    RDSUPP.K(2)=SWITCH(0,RSUP2.K,RSUPAF.K(2))
A    INSUPP.K(1)=SWITCH(0,ISUP1.K,ISUPAF.K(1))
A    INSUPP.K(2)=SWITCH(0,ISUP2.K,ISUPAF.K(2))
A    OSSUPP.K(1)=SWITCH(0,OSUP1.K,OSUPAF.K(1))
A    OSSUPP.K(2)=SWITCH(0,OSUP2.K,OSUPAF.K(2))
A    RSUP1.K=CNRD.K*(1-SCHF4.K)*SUPF.K
A    RSUP2.K=0
A    ISUP1.K=COST4.K*(1-SCHF4.K)*SUPF.K
A    ISUP2.K=COST3.K*(1-SCHF3.K)*SUPF.K
A    OSUP1.K=NWSP.K*COST.K*(1-SCHF3.K)*SUPF.K
A    OSUP2.K=(COST1.K+COST2.K)*SUPF.K
A    SUPF.K=SWITCH(1,0,SCHF1.K+SCHF2.K+SCHF3.K+
X    SCHF4.K)
NOTE    RDSUPP    R&D SUPPLEMENTAL REQUEST
NOTE    INSUPP    INVESTMENT SUPPLEMENTAL REQUEST
NOTE    OSSUPP    O&S SUPPLEMENTAL REQUEST
NOTE    RSUP      R&D SUPPLEMENTAL AMOUNT REQUESTED
NOTE    ISUP      AMOUNT OF INVESTMENT SUPPLEMENT
NOTE    OSUP      AMOUNT OF O&S SUPPLEMENT
NOTE    SUPF      SUPPLEMENT NECESSITY FACTOR
NOTE    RSUPAF    APPROVAL OF R&D SUPPLEMENT
NOTE    ISUPAF    APPROVAL OF INVESTMENT SUPPLEMENT
NOTE    OSUPAF    APPROVAL OF O&S SUPPLEMENT

```

The result of the system alternatives process establishes the plan used to acquire additional inventory, or maintain the systems already in the U.S. inventory. This is only the first part in the Planning, Programming, and Budgeting System (PPBS). The Financial Sector provides the continuation of this process and shows the transition from mission requirements to dollars required in specific appropriations.

Financial Sector

In this section, the model was developed to show the flow of funds and information which relates to funding decisions. Three categories of funds exist within the model: research and development, investment, and operating and support funding. Although these categories are not completely representative of the budget appropriations, they provide the degree of detail necessary to capture the behavior of the system. Within each funding category, two levels exist. The first level applies to one specific weapon system under review. The second level applies to all other systems which compete for funding within the particular funding category. Equations which are similar to other levels of funding categories will only be discussed once using the Research and Development dollar flow as the example.

The first group of equations correspond to the flow diagram contained in Figure 5-8.

```
L  FYDP1.K(IB)=FYDP1.J(IB)+DT*(FP1INR.JK(IB)-FP1OR.JK(IB))
R  FP1OR.KL(IB)=RDRQT.K(IB)
NOTE  FYDP1  R&D EXPENDITURES PLANNED IN THE FYDP
NOTE  FP1INR  R&D COSTS INPUT TO THE FYDP
NOTE  FP1OR  R&D COSTS FUNDED FROM THE FYDP
NOTE  RDRQT  R&D FUNDS REQUIREMENT
L  RDRB.K(IB)=RDRB.J(IB)+DT*(RDMDR.JK(IB)-RREDR.JK(IB))
R  RDMDR.KL(IB)=RDRQT.K(IB)
R  RREDR.KL(IB)=RDAR.JK(IB)
NOTE  RDRB  R&D DOLLARS REQUESTED IN THE BUDGET
NOTE  RDMDR  R&D DEMAND RATE
NOTE  RREDR  R&D DEMAND REDUCTION RATE
NOTE  RDRQT  R&D FUNDS REQUIREMENT
NOTE  RDAR  R&D ALLOCATION RATE
```

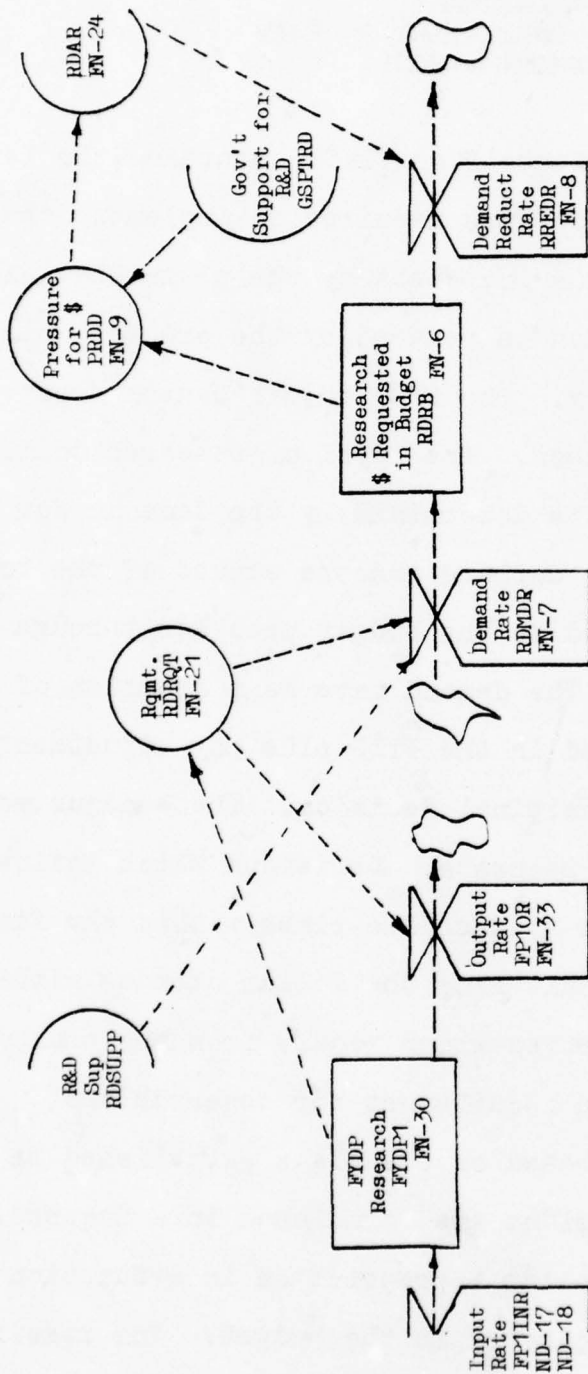


Figure 5-8
Financial Sector--Programming and Budgeting

A RDRQT,K(IB)=FYDP1,K(IB)*PULSE(1,11,12)+RDSUPP,K(IB)
 NOTE RDRQT R&D FUNDS REQUIREMENT
 NOTE FYDP1 R&D EXPENDITURES PLANNED IN THE FYDP
 NOTE RDSUPP R&D SUPPLEMENTAL REQUEST

The Five Year Defense Plan (FYDP) contains the level of forces and estimated dollars required to implement the force plan. This level is increased by the plans that are created in the process and is reduced by the process which updates the FYDP annually. The FYDP requirements become the input to the budget request. The level of research dollars requested in the budget is determined by the demands for research and development dollars and the amount of the total demand which is satisfied as the budget proceeds through the various review levels. The demand rate is a function of both the amount contained in the FYDP plus any adjustments made to supplement the original decision. These adjustments are called supplemental requests. Decisions which influence the budget request occur at specific times within the fiscal year. The decisions result from the dollar amounts within each level and the pressures which result from the changing system environment. The requirement for research and development dollars is based on the plans established in the FYDP. Annually, these plans are formulated in a request. Similarly, the actual dollar appropriation is a function of the level of funding requested in the budget. For research

and development, the equations which determine the amount and result of pressure for a specific appropriation are given below:

```

A  PRDD.K(IB)=GSPTRD.K(IB)+RDRB.K(IB)
NOTE  PRDD  PRESSURE FOR R&D DOLLARS
NOTE  GSPTRD  GOVERNMENT SUPPORT FOR R&D
NOTE  RDRB  R&D DOLLARS REQUESTED IN THE BUDGET
R  RDAR.KL(IB)=PRDD.K(IB)*PULSE(1,10,12)
NOTE  RDAR  R&D APPROPRIATION RATE
NOTE  PRDD  PRESSURE FOR R&D DOLLARS

```

The actual appropriation of dollars contained in the budget depends on the pressure for research and development dollars (PRDD). This pressure results from both the magnitude of the budget request as well as from government support for research and development programs.

The system structures for investment and operating and support funding are identical to the structure for research and development. The flow diagrams and the systems equations which apply to these funding categories are contained in Appendix C.

In addition to the discussion of the separate funding categories, the equations which apply to the total DOD budget (DDRB) follow.

```

L  DDRB.K(IB)=DDRB.J(IB)+DT*(DDMDR.JK(IB)-DREDR.JK(IB))
R  DDMDR.KL(IB)=RDRQT.K(IB)+IRQT.K(IB)+ORQT.K(IB)
R  DREDR.KL(IB)=RDAR.JK(IB)+IDAR.JK(IB)+OSDAR.JK(IB)
NOTE  DDRB  DEFENSE DOLLARS REQUESTED IN THE BUDGET
NOTE  DDMDR  DEFENSE DEMAND RATE
NOTE  DREDR  DEFENSE DEMAND REDUCTION RATE

```

NOTE	RDRQT	R&D FUNDS REQUIREMENT
NOTE	ORQT	O&S FUNDS REQUIREMENT
NOTE	IRQT	INVESTMENT FUNDS REQUIREMENT
NOTE	RDAR	R&D APPROPRIATION RATE
NOTE	IDAR	INVESTMENT APPROPRIATION RATE
NOTE	OSDAR	O&S APPROPRIATION RATE

The DOD budget (Figure 5-9) is the sum of the dollars requested for the three funding categories. The information about the DOD budget is used in the political sector to determine the characteristics of the Federal budget. Decisions are made annually according to the fiscal year cycles established by law.

The appropriation and expenditure of research dollars is depicted in the flow diagram contained in Figure 5-10. In this section of the financial sector, some of the equations differ between the two levels within the funding categories. Whenever possible, variables which apply to the first level were placed on the upper portion of the flow diagram and equations for the second level were placed on the lower portion of the diagram. The model assumes that transfers between these two levels are possible; however, no provision for transfers between funding categories is developed in the equation system. Transfers of funds between appropriation categories is not a common practice in the real system. The first group of equations are:

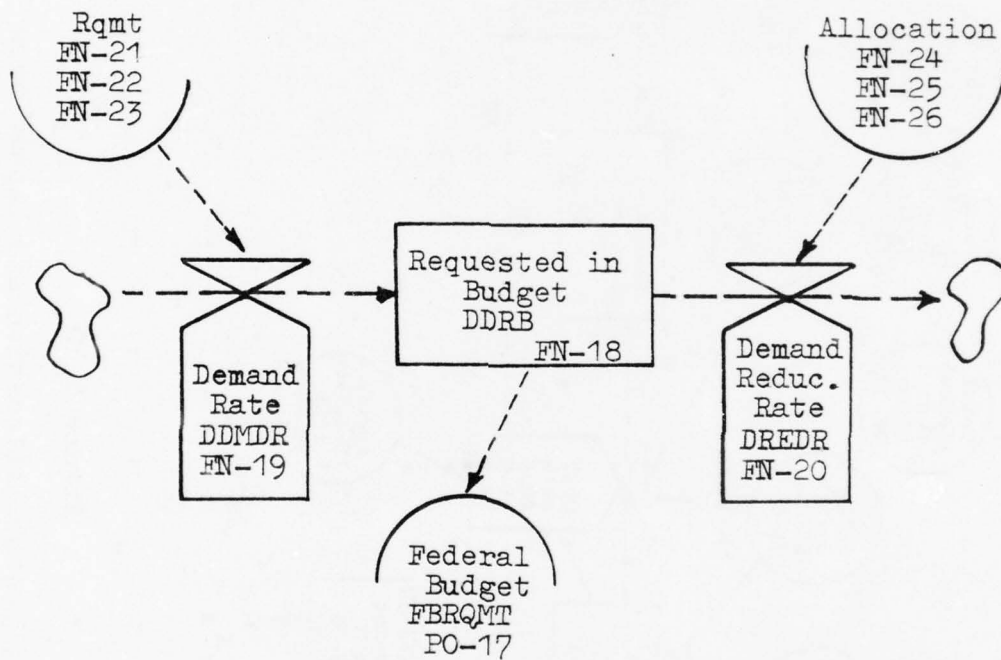


Figure 5-9
Financial Sector--DOD Budget

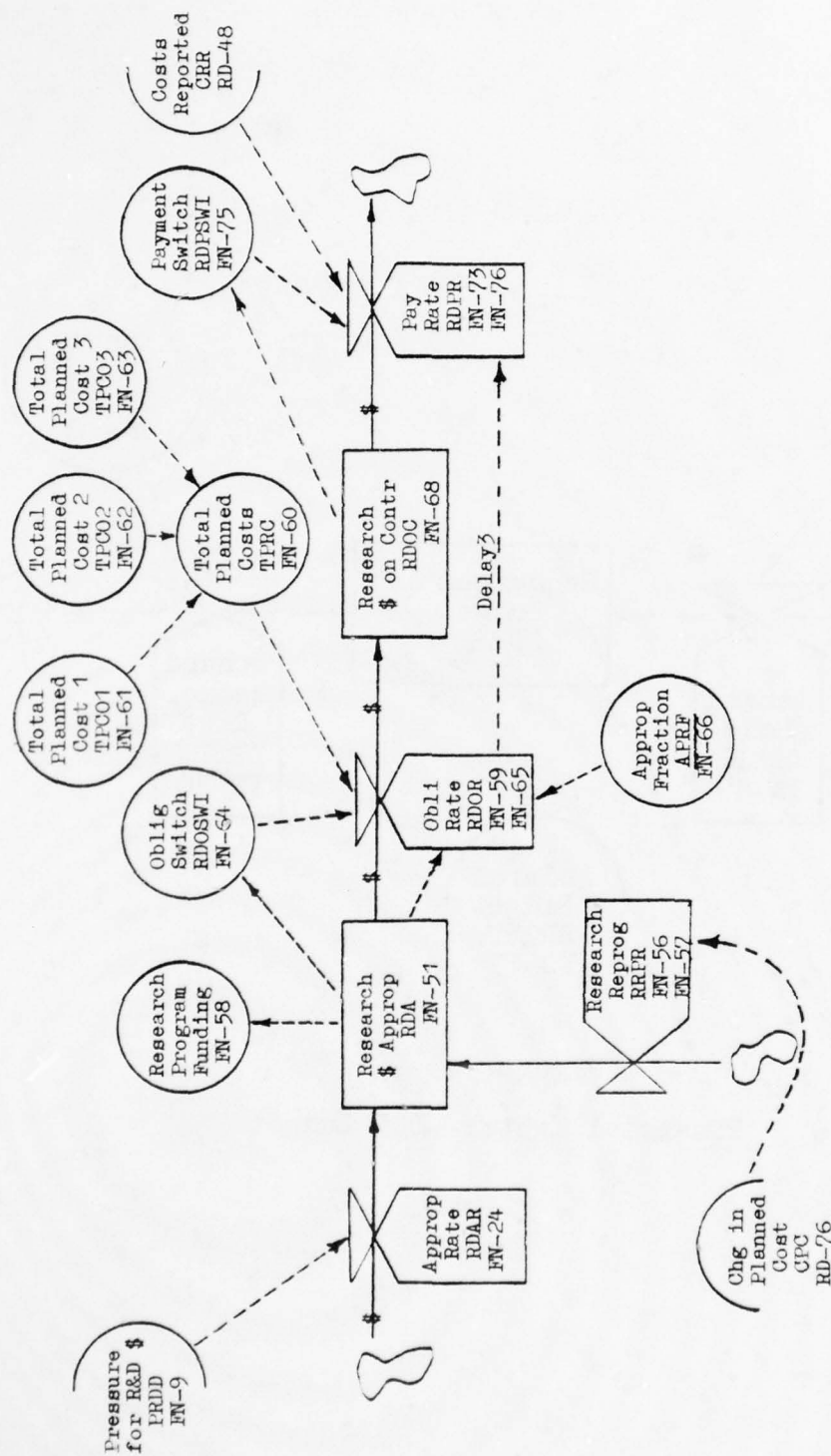


Figure 5-10
Financial Sector--Allocation and Expenditure


```

L  RDA.K(P)=RDA.J(P)+DT*(RDAR.JK(P)-RDOR.JK(P)+RRPR.JK(P))
R  RRPR.KL(1)=CPC1.K+CPC2.K+CPC3.K
R  RRPR.KL(2)=-(CPC1.K+CPC2.K+CPC3.K)
R  RDOR.KL(1)=TPRC.K*RDOSWI.K(1)
R  RDOR.KL(2)=(RDA.K(2)*APRF.K)*RDOSWI.K(2)
NOTE  RDA      RESEARCH DOLLARS APPROPRIATED
NOTE  RDAR     R&D APPROPRIATION RATE
NOTE  RDOR     RESEARCH DOLLARS OBLIGATION RATE
NOTE  RRPR     RESEARCH REPROGRAMMING RATE
NOTE  TPRC     TOTAL PLANNED RESEARCH COSTS
NOTE  CPC      CHANGE IN PLANNED COSTS
NOTE  RDOSWI   RESEARCH DOLLARS OBLIGATION SWITCH

```

The level of research dollars available for DOD spending is based on the amount of research dollars appropriated annually, the rate research dollars are obligated, and the rate that research dollars are reprogrammed from other programs. As weapon system plans are developed, the estimated dollars required to implement the plan are obligated on a contract. These dollars are obligated at the time that the contract is signed. The obligation rate has a switch to ensure that obligations do not exceed the total research dollars appropriated for a given program or level. For the second level, a less detailed approach was used to develop system equations. The obligation rate is based on desires to spread spending throughout the year. An appropriation fraction is used to determine the amount of time remaining in the year in order to provide stable spending patterns as the fiscal year proceeds. Reprogramming of research dollars involves transferring funds from one

account to another. In this model, level two dollars are transferred to level one if the decision is made to approve a change in planned costs for one of the research and development phases. Several self-explanatory auxiliary equations apply to the previous equation set. They are:

```

A  RPF.K=SWITCH(0,1,RDA.K(1))
A  RDOSWI.K(P)=SWITCH(0,1,RDA.K(P))
NOTE  RPF      RESEARCH PROGRAM FUNDING
NOTE  RDA      RESEARCH DOLLARS APPROPRIATED
NOTE  RDOSWI   RESEARCH DOLLARS OBLIGATION SWITCH
A  APRF.K=TABLE(APRFT,FYTIME,K,1,12,1)
T  APRFT=1.0/.5/.33/.25/.2/.167/.143/.125/.111/.1/.091/.083
A  TPRC.K=TPC01.K+TPC02.K+TPC03.K
A  TPC01.K=(TPC1.K+WSD1.K+DSWI1.K)+CPC1.K
A  TPC02.K=TPC2.K+WSD2.K+DSWI2.K+CPC2.K
A  TPC03.K=TPC3.K+WSD3.K+DSWI3.K+CPC3.K
NOTE  TPRC     TOTAL PLANNED RESEARCH COSTS
NOTE  TPC0     TOTAL PLANNED COSTS OBLIGATED(BY PHASE)
NOTE  WSD      WEAPON SYSTEM DEVELOPMENT DECISION
NOTE  DSWI     DOLLAR SWITCH(BY PHASE)
NOTE  CPC      CHANGE IN PLANNED COSTS
NOTE  FYTIME   TIME IN FISCAL YEAR

```

Work on research and development programs cannot begin without funding and a signed contract. A switch function is used to note the availability of funds. If funds are exhausted, work must stop until additional funding is obtained or the program is cancelled. To ensure that funds are not over obligated, continual monitoring of funding status occurs. Funds are obligated as total planned costs are determined and placed on research and development contracts. Costs are developed from the

original estimates of planned costs and any changes which are approved. The dollar switch and weapon system decision switch ensure that the total planned costs are obligated only once—on the first day of a research and development phase.

The second section of equations focuses on the level of research dollars on contract (RDOC).

```

L  RDOC.K(P)=RDOC.J(P)+DT*(RDOR.JK(P)-RDPR.JK(P))
R  RDPR.KL(1)=RDPSWI.K(1)*(DELAY3(CRR1.JK,RDPRD)+DELAY3(CRR2.JK,
X  RDPRD)+DELAY3(CRR3.JK,RDPRD))
R  RDPR.KL(2)=DELAY3(RDOR.JK(2),RDPRD)
NOTE  RDOC  RESEARCH DOLLARS ON CONTRACT
NOTE  RDOR  RESEARCH DOLLARS OBLIGATION RATE
NOTE  RDPR  RESEARCH DOLLARS PAYMENT RATE
NOTE  RDPSWI RESEARCH DOLLAR PAYMENT SWITCH
NOTE  CRR   COST REPORTING RATE(BY PHASE)
NOTE  RDPRD RESEARCH DOLLARS PAYMENT RATE DELAY
A  RDPSWI.K(P)=SWITCH(0,1,RDOC.K(P))
NOTE  RDPSWI RESEARCH DOLLARS PAYMENT SWITCH
NOTE  RDOC  RESEARCH DOLLARS ON CONTRACT

```

The level of dollars on contract is increased by obligations that result from signing or amending contracts. The level is reduced as payments are made for contractual work. These payments are normally made as progress towards the final product is achieved. As costs are reported from the work accomplished in a research and development project, progress payments are paid to the contractor. The payment rate for level-two contracts is simply expressed as a delay function representing the average time necessary to complete work related to a research and development contract. A payment

switch ensures that payments do not exceed the amount of dollars on contract. Contract amendments are required if cost expenditures exceed the amount of dollars obligated to the contract.

The flow diagrams and equation set for investment funds is very similar to research and development funding. The difference is that only the production sector provides the input concerning costs. The flow diagram and the system equations are contained in Appendix C.

The operating and support funds structure is also similar to the other funding categories. However, several differences were included in the model because there is less visibility and control over costs in this area. This allows for more flexibility to transfer funds between levels by means of reallocation rather than by reprogramming. Reallocation does not require such extensive a review and approval cycle, therefore, more flexibility exists. Operating and support funds are reallocated based on the decision to transfer monies between two or more programs. This decision is based on the magnitude of the requirement, the dollar availability from other programs, and the mission area importance related to the funding reallocation request. The result of this decisional process determines the percent of dollars that will be reallocated.

Strategic-level managers have little visibility and control over costs directly related to operation and support of specific weapon system programs. Their primary information is presented in aggregate form rather than by system. At this level, the objective is to provide support throughout the year by ensuring that spending is fairly stable. When problems occur in one program, first the monies allocated to that specific program are expended, accelerating demands for funds. After the assigned source of funds is exhausted, reallocation from other programs may occur.

The flow of funds directly affects the activities that DOD can pursue. In the acquisition process one of the first set of costs is related to the search for technology in order to maintain the technology base and meet specific goals resulting from needs.

Technology Sector

The Technology Sector flow diagram depicted in Figure 5-11 shows the flow of technology through the system. The level of technology is measured in terms of the present technology base. Using an index of one hundred as a reference point, the level increases or decreases as the system moves through time. The following equations and discussion describe the system flow of technology.

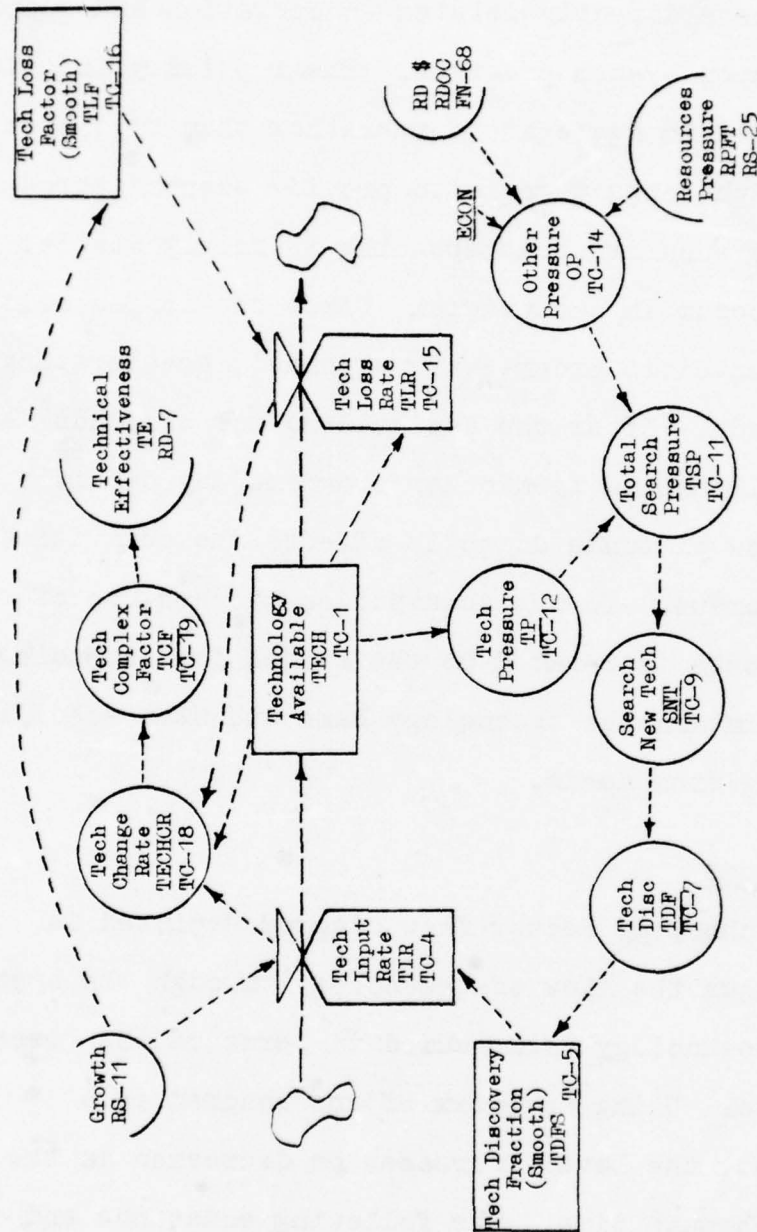


Figure 5-11

Technology Sector

```

L  TECH.K=TECH.J+DT*(TIR.JK-TLR.JK)
R  TIR.KL=TECH.K*(GROWTH.K+TDFS.K)
R  TLR.K=SMOOTH(GROWTH.K,TLFD)
NOTE    TECH    TECHNOLOGY AVAILABLE
NOTE    TIR     TECHNOLOGY INPUT RATE
NOTE    TLR     TECHNOLOGY LOSS RATE
NOTE    GROWTH  GROWTH FACTOR
NOTE    TDFS    TECHNOLOGY DISCOVERY FRACTION(SMOOTHED)

```

The level of available technology (TECH) is increased by the inputs to technology from research and development and industrial growth throughout the world, as well as by specific pressure to meet technology goals set by DOD. Technology is lost as time passes and technology becomes obsolete. As the rate of input to technology increases, the aging process also accelerates. This is due to the accumulation of many new technologies which replace or overshadow previous technological achievements.

The second set of equations pertains to the pressures to increase the rate of new technological discoveries. The equations are:

```

A  TDFS.K=SMOOTH(TDF.K,TDFD)
A  TDF.K=TABHL(TDFT,SNT.K,0,1,.2)/12
T  TDFT=.01/.03/.07/.1/.12/.13
NOTE    TDFS    TECHNOLOGY DISCOVERY FRACTION(SMOOTHED)
NOTE    TDF     TECHNOLOGY DISCOVERY FRACTION
NOTE    SNT     SEARCH FOR NEW TECHNOLOGY
NOTE    TDFD    TECHNOLOGY DISCOVERY FRACTION DELAY
A  SNT.K=TABHL(SNTT,TSP.K,0,.15,.03)
T  SNTT=.1/.15/.32/.52.80/1.0
A  TSP.K=TP.K+OP.K
A  TP.K=TABHL(TPT,TECH.K,0,100,10)
T  TPT=1/1/.8/.5/.27/.1

```

$A \quad OP.K = \text{SUM}(RDOC.K) / \text{ECON} * RPFT.K$
 NOTE SNT SEARCH FOR NEW TECHNOLOGY
 NOTE TSP TOTAL SEARCH PRESSURE
 NOTE TP TECHNOLOGY PRESSURE
 NOTE OP OTHER PRESSURE
 NOTE TECH TECHNOLOGY AVAILABLE
 NOTE RDOC RESEARCH DOLLARS ON CONTRACT
 NOTE ECON ECONOMIC BASELINE FACTOR
 NOTE RPFT RESOURCES PRESSURE FOR TECHNOLOGY

As a result of pressures, new technologies are discovered. These discoveries gradually become apparent to the system as the technology is applied. The percent of increase is based on the pressures to search for new technology. These pressures result from general efforts to maintain or increase technology, based on the existing level of technology. Other pressures for technology result from specific efforts within DOD. The amount of research and development dollars on contract is used to measure the relative pressures by DOD for technology. In addition to this pressure, the level of resources also places a demand for technology as raw materials become scarce. As the pressure to search for new technology increases, the rate of discovery also increases. This increase occurs at a decreasing rate of growth as the limit approaches.

The final equation set for the technology sector includes:

A $TECHCR.K = (TIR.JK - TLR.JK) / TECH.K$
 A $TCF.K = TABHL(TCFT, TECHCR.K, 0, .2, .02)$
 T $TCFT = 2.0 / 1.95 / 1.85 / 1.7 / 1.45 / 1.0 / .67 / .5 / .35 / .3 / .25$
 NOTE TECHCR TECHNOLOGY CHANGE RATE
 NOTE TCF TECHNICAL COMPLEXITY FACTOR
 NOTE TIR TECHNOLOGY INPUT RATE
 NOTE TLR TECHNOLOGY LOSS RATE
 NOTE TECH TECHNOLOGY AVAILABLE

The rate and magnitude of the changes in technology indicate the technological advancement which is perceived. Within DOD, the goal to reach out for state-of-the-art technology is affected by this technological advancement. If the rate of change is rapid, the expected technical problems should be lower than if the same technology goals were established and the rate of technological advancement were slower. The technical complexity attributed to DOD acquisitions is a function of the rate of technology change. The technical complexities which exist have a direct impact on the amount of real progress in both research and development and production efforts.

Research and Development Sector

The research and development sector is divided into three similar parts to represent the research and development phases established for major weapon systems acquisitions. These phases include: Conceptual Effort, Validation, and Full-Scale Development. Due to the similarities in model structure, only one phase will be used as an example.

The flow diagrams and equation presentation will discuss the flow of information, progress, and cost reporting through a research and development phase. The first part of this section will focus on the flow of progress and the corresponding information loops applicable to managing a research and development effort. The flow diagram depicted in Figure 5-12 and the following equations provide the basis for starting a research and development phase.

```

L  PP1.K=PP1.J+DT*(PPGM1.JK-PPTX1.JK)
R  PPGM1.KL=TABLE(PCMIT,PSCHD1.K,0,1,.0033)*WSD1.K+DCP1.K
X  *12/TICP.K
A  PSCHD1.K=TSMS0.K/TICP.K
NOTE    PP1    PLANNED PROGRESS
NOTE    PPGM1  PLANNED PROGRESS RATE
NOTE    PPTX1  PLANNED PROGRESS TRANSFER RATE
NOTE    WSD    WEAPON SYSTEM DEVELOPMENT DECISION
NOTE    DCP    DECISION COORDINATING POINT
NOTE    TICP   TIME IN CONCEPTUAL PHASE
NOTE    PSCHD1 PLANNED SCHEDULE
NOTE    TSMS0  TIME SINCE MILESTONE 0

```

The plan for progress is determined by the estimated work effort required to accomplish research and development. This plan is measured by man months. The total estimated man months required is assumed to be given. The progress rate can then be expressed in terms of the percent of the total project which is completed each month. The progress rate relates to the monthly work schedules which are established. Using a typical program buildup, the graph in Figure 5-13 was used to represent the planned work

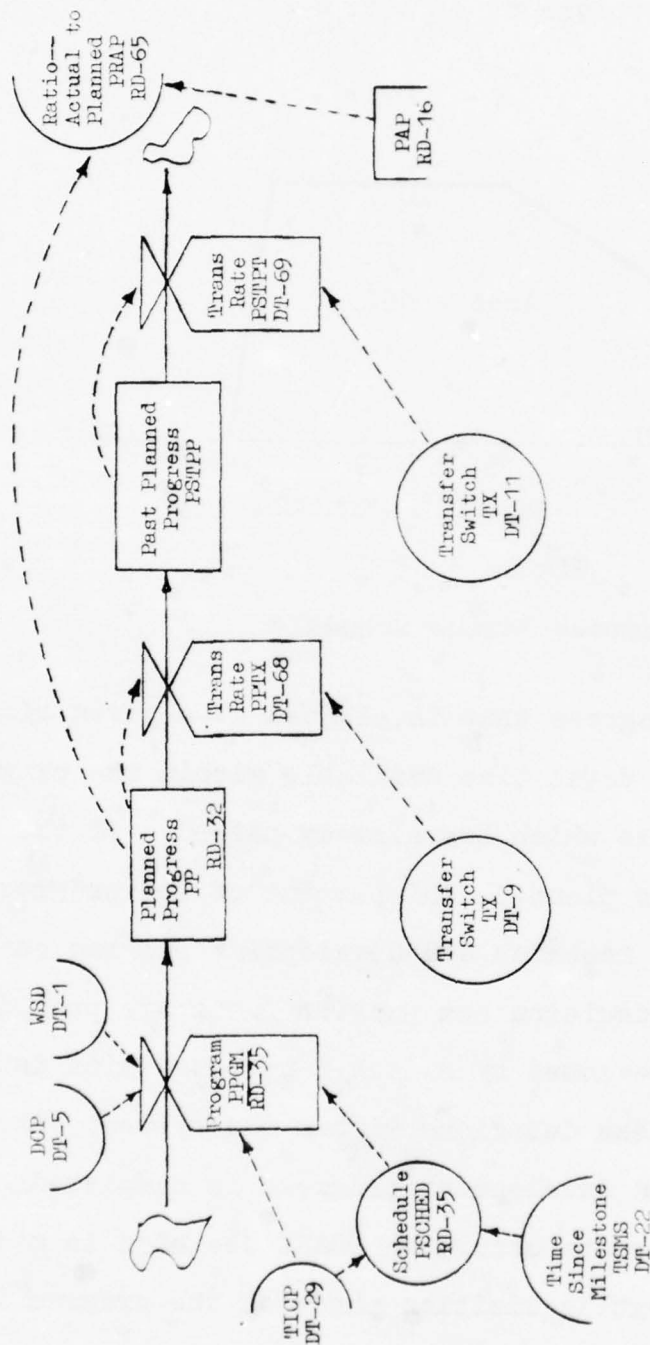


Figure 5-12
Weapon System Development--Planned Progress

schedule which was programmed for the various times throughout a research and development effort.

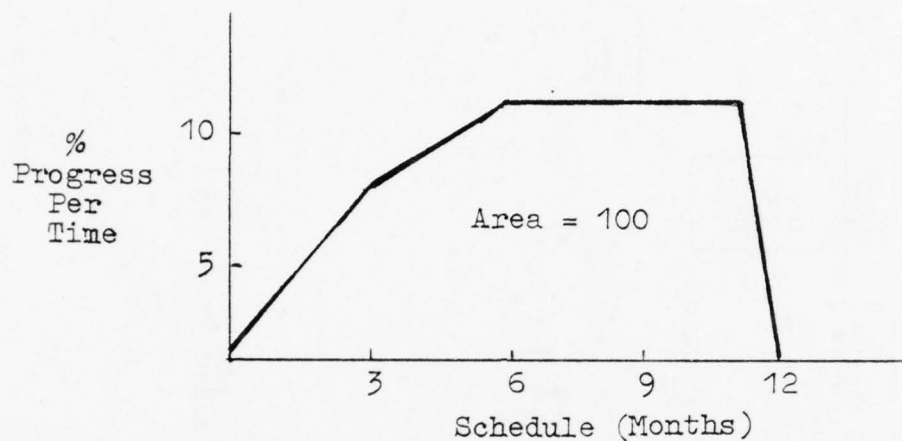


Figure 5-13

Progress Versus Schedule

The percentage of progress that is planned at a given time is a function of the total time available within the program and the amount of time which has already passed. If the program progresses as planned, 100 percent of the progress goal is achieved. A research and development program cannot begin until a DSARC decision and program funds are provided. This concept is represented by switch functions which determine the state of these decisions within the system. The plan for research and development progress is completed when either of two events occur: a DSARC decision is made to proceed to the next acquisition phase or the program is cancelled. At this time, the level of progress is emptied.

In many cases, the actual progress made on a research and development program is not the same as the planned progress. This is due to the uncertainties that characterize the research and development task. The following equations pertain to actual progress:

```

L  AP1.K=AP1.J+DT*(APR1.JK-APTR1.JK)
R  APR1.KL=TE1.K+PGM1.K*CAPRS1.K
A  TE1.K=TCF.K*ME1
NOTE  AP1  ACTUAL PROGRESS
NOTE  APR1  ACTUAL PROGRESS RATE
NOTE  APTR1  ACTUAL PROGRESS TRANSFER RATE
NOTE  TE1  TECHNICAL EFFECTIVENESS
NOTE  PGM1  PROGRAM
NOTE  CAPRS1  CHANGE IN ACTUAL PROGRESS RATE
NOTE  TCF  TECHNICAL COMPLEXITY FACTOR
NOTE  ME1  MANAGEMENT EFFECTIVENESS FACTOR
A  PGM1.K=TABHL(PGM1T,SCHED1.K,0,1,.0833)*WSD1.K+DCP1.K*
X  12/(TTMS1.K+TSMS0.K)
T  PGM1T=0/3/6/7.5/9/9.67/10.33/11/11/11/11/11
T  PGM1T=0/3/6/7.5/9/9.67/10.33/11/11/11/11/11/0
A  SCHED1.K=TSMS0.K/(TSMS0.K+TTMS1.K)
A  CAPRS1.K=SMOOTH(CAPR1.K,CAPRD)
NOTE  PGM1  PROGRAM
NOTE  SCHED1  SCHEDULE
NOTE  WSD1  WEAPON SYSTEM DEVELOPMENT DECISION
NOTE  DCP1  DECISION COORDINATING POINT
NOTE  TTMS1  TIME TO MILESTONE 1
NOTE  TSMS0  TIME SINCE MILESTONE 0
NOTE  CAPRS1  CHANGE IN ACTUAL PROGRESS RATE(SMOOTHED)
NOTE  CAPRD  CHANGE IN ACTUAL PROGRESS SMOOTHING CONSTANT

```

The level of actual progress (Figure 5-14) is determined by the programmed rate of progress, adjusted by the degree of technical effectiveness within the research and development program and the changes which result from evaluations of the work effort. The level of progress is accumulated throughout the research and development phase until a DSARC decision is made to proceed to the next phase or to cancel

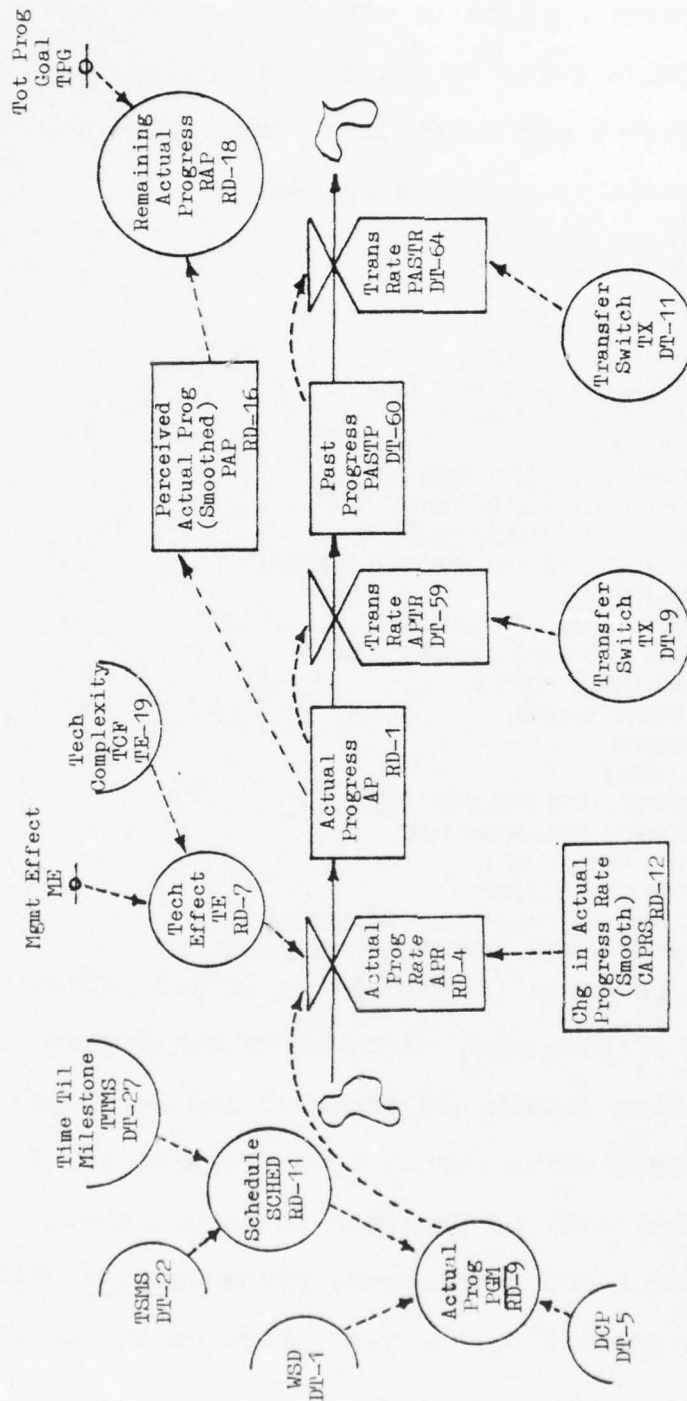


Figure 5-14
Weapon System Development--Actual Progress

the program. At this time, the progress is removed from its current level and added to the historical records of research and development programs. This is similar to the activity which occurs for the planning aspects of research and development. The programmed rate of progress is based on the original schedule established in the plan and any adjustments which have been approved to change the schedule. The difference between actual and planned progress is caused by two general factors. First, technical effectiveness measures the degree that the contractor is successful in dealing with the technical challenges which exist in research and development. This is based on the technical complexity associated with the program and the research and development management expertise within the firm. The second determinant of the actual progress rate is the change which results from the evaluation of progress. The change in actual progress is adjusted gradually to avoid wide fluctuations in the progress rate which may cause excessive overtime, hiring, or layoffs of personnel. The evaluation which results in the change in actual progress begins with a determination evaluation of the perceived actual progress. The equations below explain the concept.


```

A PAP1.K=SMOOTH(API.K,APD)
A RAP1.K=TPG-PAP1.K
NOTE PAP1 PERCEIVED ACTUAL PROGRESS
NOTE API ACTUAL PROGRESS
NOTE APD ACTUAL PROGRESS DELAY
NOTE RAP1 REMAINING ACTUAL PROGRESS
NOTE TPG TOTAL PROGRESS GOAL

```

The perception of actual progress (PAP) reflects the fact that managers do not have the ability or the information to make instantaneous evaluations of the situation. This results in a delay, causing decisions to be made on the perceived rather than the actual situation. The evaluation begins with a comparison of the perceived actual progress and the total progress goal. This comparison determines the amount of progress that remains. From this information, the manager begins to assess the situation to determine the best way to adjust the work effort to create minimum disruption in both planned progress schedules and planned cost. This decision is represented in the following equations which determine the relative penalties which exist in altering the performance (progress), schedule, and cost aspects of the research and development effort. These equations correspond to the flow diagram contained in Figure 5-15.

```

A PRR1.K(I)=RAP1.K/RTTMS1.K(I)
A RTTMS1.K(I)=TTMS1.K+T(I)
A CP1.K(I)=CF1.K(I)*RTTMS1.K(I)
A CF1.K(I)=TABHL(CFT,PRR1.K(I),.6,1.6,.1)
T CFT=1.15/1.06/1.02/1.01/1/1.1/1.25/1.32/1.62/2/3

```

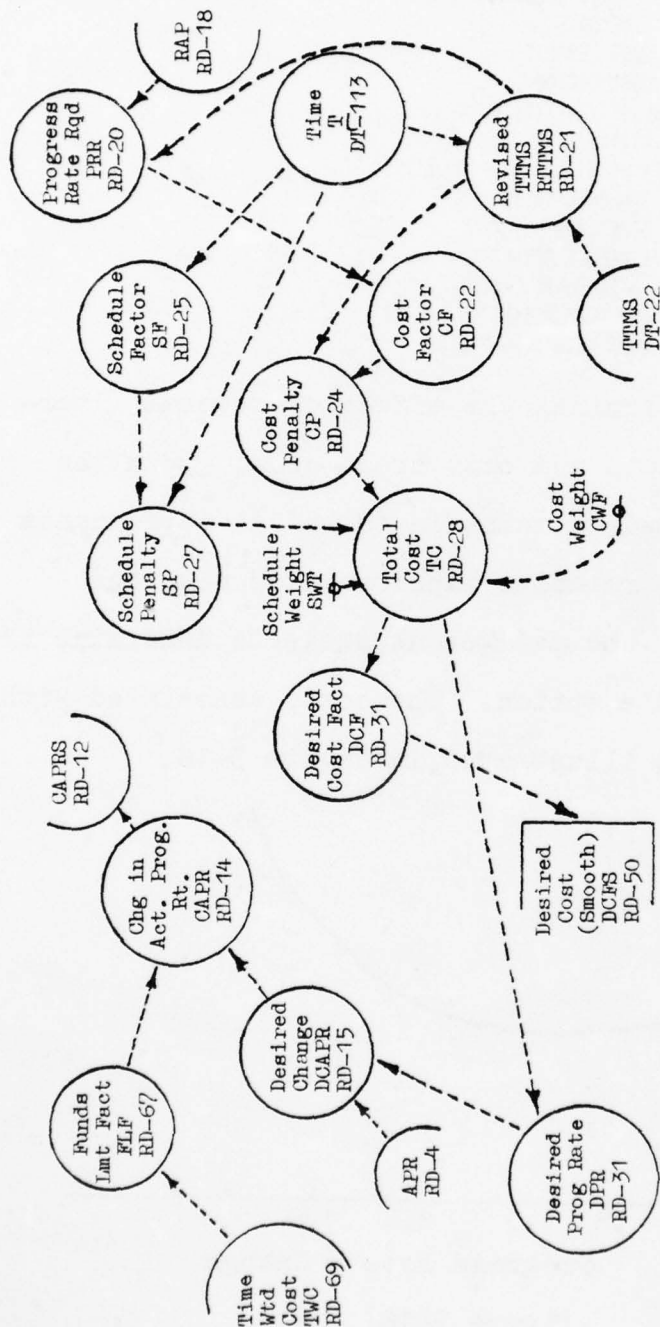


Figure 5-15
Weapon System Development--Cost and Schedule Tradeoff

```

NOTE   PRR1   PROGRESS RATE REQUIRED
NOTE   RAP1   REMAINING ACTUAL PROGRESS
NOTE   RTTMS1 REVISED TIME TO MILESTONE 1
NOTE   TTMS1  TIME TO MILESTONE 1
NOTE   T      TIME LATE
NOTE   CP1    COST PENALTY
NOTE   CF1    COST FACTOR
A   SF1.K(I)=TABHL(SFT,T(I),1,10,1)
A   SP1.K(I)=SF1.K(I)*T(I)
A   TC1.K(I)=(CWF*CP1.K(I))+(SWF*SP1.K(I))
NOTE   SF1    SCHEDULE FACTOR
NOTE   T      TIME LATE
NOTE   SP1    SCHEDULE PENALTY
NOTE   TC1    TOTAL PENALTY COST
NOTE   SWF    SCHEDULE WEIGHTING FACTOR
NOTE   CWF    COST WEIGHTING FACTOR

```

Management first determines the effect of several alternative sets of schedule and cost trade-offs, given the progress rate required to maintain technical performance goals. Based on the relative importance of cost and schedule deviations, the management seeks to determine the best cost and schedule option. The costs associated with these trade-offs are illustrated in Figure 5-16.

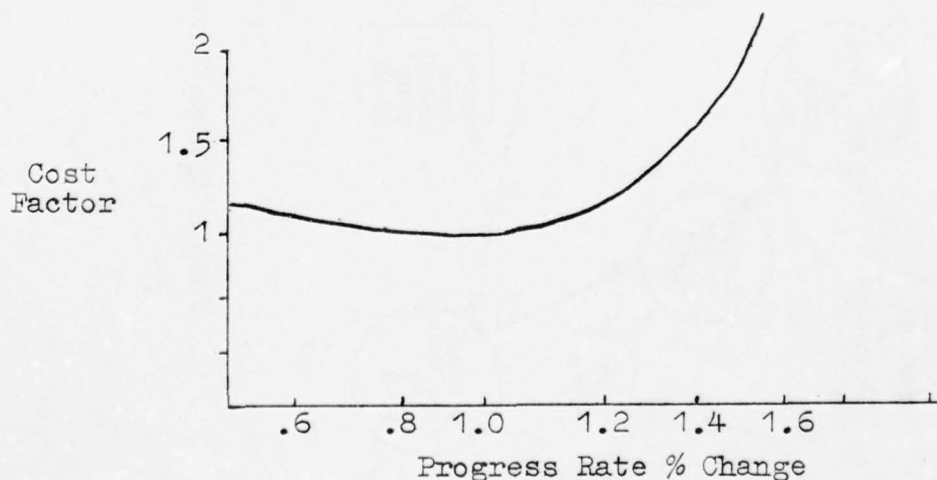


Figure 5-16

Cost Versus Progress Rate

As the progress rate is increased, the costs also increase due to overtime payments and increased hiring. A small increase can be made as the result of increased productivity of the work force. Therefore, the curve is relatively flat closer to the point where the planned progress rate lies. The actual contractual arrangement for each program determines the shape of the curve. Incentives for cost control may influence the weights established for cost and schedule considerations in the decisional process.

The costs associated with being late in contract completion are depicted in Figure 5-17. As the time late

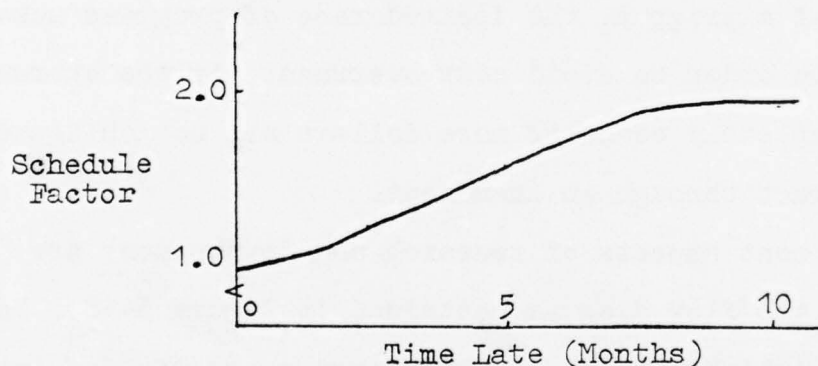


Figure 5-17

Schedule Versus Time Late

becomes very long, the penalties become less meaningful than in the earlier times. The research indicated that there is little motivation to come in ahead of schedule.

The model contains a subroutine which selects the best alternative relative to the implicit and explicit costs associated with changing the desired progress rate. The new progress rate desired is the output of this analysis. The decision which results is implemented gradually within the work effort. This decision is reflected below.

```

A  CAPRI.K=FLF1.K*DCAPRI.K
NOTE  CAPRI  CHANGE IN ACTUAL PROGRESS
NOTE  FLF1   FUNDS LIMIT FACTOR
NOTE  DCAPRI DESIRED CHANGE IN ACTUAL PROGRESS RATE

```

The desired change in the progress rate is also influenced by the amount of funds available. If funds begin to run out at the end of a program, the desired rate of progress must be reduced in order to avoid cost overruns. At the extreme, work can completely cease if more dollars are not obligated to the contract through an amendment.

The cost aspects of research and development are depicted in the flow diagram contained in Figure 5-18. The equations which correspond to this diagram are divided into two sections. The first equation set is:

```

L  PC1.K=PC1.J+DT*(PCR1.JK-PCTR1.JK)
R  PCR1.KL=PPGM1.JK/PTCR+CPC1.K
A  TPC1.K=TPG/PTCR+CPC1.K
NOTE  PC1   PLANNED COSTS
NOTE  PCR1  PLANNED COST RATE
NOTE  PCTR1 PLANNED COST TRANSFER RATE
NOTE  PPGM1 PLANNED PROGRAM RATE
NOTE  PTCR  PROGRESS TO COST RATIO

```

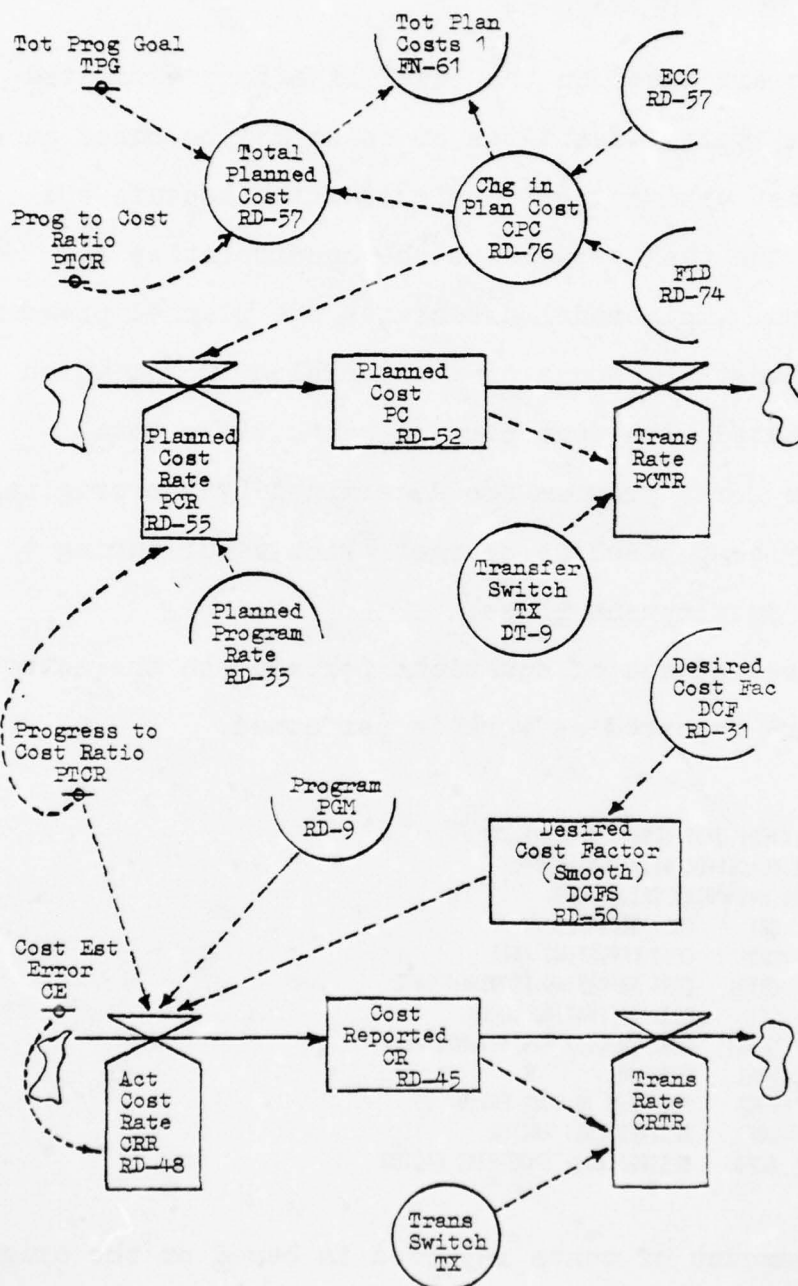



Figure 5-18

Weapon System Development--Planned and Actual Cost

NOTE	CPC1	CHANGE IN PLANNED COST
NOTE	TPC1	TOTAL PLANNED COST
NOTE	TPG	TOTAL PROGRESS GOAL

Planned costs are based on the level of effort estimated prior to work start. Estimates of costs may be based on a variety of cost estimating techniques which measure the magnitude of the task as well as the uncertainties and risks involved. This model associates the planned program with planned costs by means of a conversion factor which can be associated with cost per man month. The total planned costs for a program are determined by the original plan plus any cost baseline changes which occur during the research and development phase.

The second set of equations pertains to the actual costs that are reported as work is performed.

L	$CR1.K = CR1.J + DT * (CRR1.JK - CRTR1.JK)$	
R	$CRR1.KL = CE1 * DCFS1.K * PGM1.K / PTCR$	
A	$DCFS1.K = SMOOTH(DCF1.K, DCFD)$	
NOTE	CR1	COST REPORTED
NOTE	CRR1	COST REPORTING RATE
NOTE	CRTR1	COST REPORTING TRANSFER RATE
NOTE	CE1	COST ESTIMATING ERROR
NOTE	DCFS1	DESIRED COST FACTOR(SMOOTHED)
NOTE	PGM1	PROGRAM
NOTE	PTCR	PROGRESS TO COST RATIO
NOTE	DCF1	DESIRED COST FACTOR
NOTE	DCFD	DESIRED COST SMOOTHING FACTOR

The amount of costs reported is based on the original cost rates plus any adjustments resulting from changes to

the progress rate or unanticipated changes due to cost estimation errors.

As the research and development program continues, the cost and schedule status are monitored closely. Pressures to delay a milestone decision are increased as schedule changes occur in the evaluation process. The equations which represent this process are given below. These equations correspond to the flow diagram contained in Figure 5-19.

```

A  PSE1.K=TABHL(PSET,ELF1,K,0,1,2)
T  PSET=0.0/.15/.35/.58/.88/1.0
A  ELF1.K=DTL1.K/TTMS1.K
NOTE  PSE1  PRESSURE FOR SCHEDULE EXTENSION
NOTE  ELF1  ESTIMATED LATE FACTOR
NOTE  DTL1  DESIRED TIME LATE
NOTE  TTMS1 TIME TIL MILESTONE 1
NOTE  USURCF US URGENCY FACTOR
A  SEA1.K=PSE1.K*CRPA1.K/USURCF.K
A  CRPA1.K=PC1.K/CR1.K
A  SCD1.K=CLIP(SEA1.K,0,SEA1.K,.5)
A  SCDM1.K=CLIP(1,SCD1.K,SCD1.K,1)
A  CMS1.K=SCDM1.K*DTL1.K
NOTE  SEA1  SCHEDULE EXTENSION ADJUSTOR
NOTE  CRPA1  COST RATIO(PLANNED TO ACTUAL)
NOTE  PC1  PLANNED COST
NOTE  CR1  COST REPORTED
NOTE  SCD1  SCHEDULE EXTENSION DECISION
NOTE  SCDM1 SCHEDULE MULTIPLIER
NOTE  CMS1  CHANGE IN MILESTONE 1

```

The decision to approve a schedule delay is based upon the intensity of the pressures to extend the schedule, the urgency of the requirement, and the cost performance expressed as the ratio of planned to actual costs. If

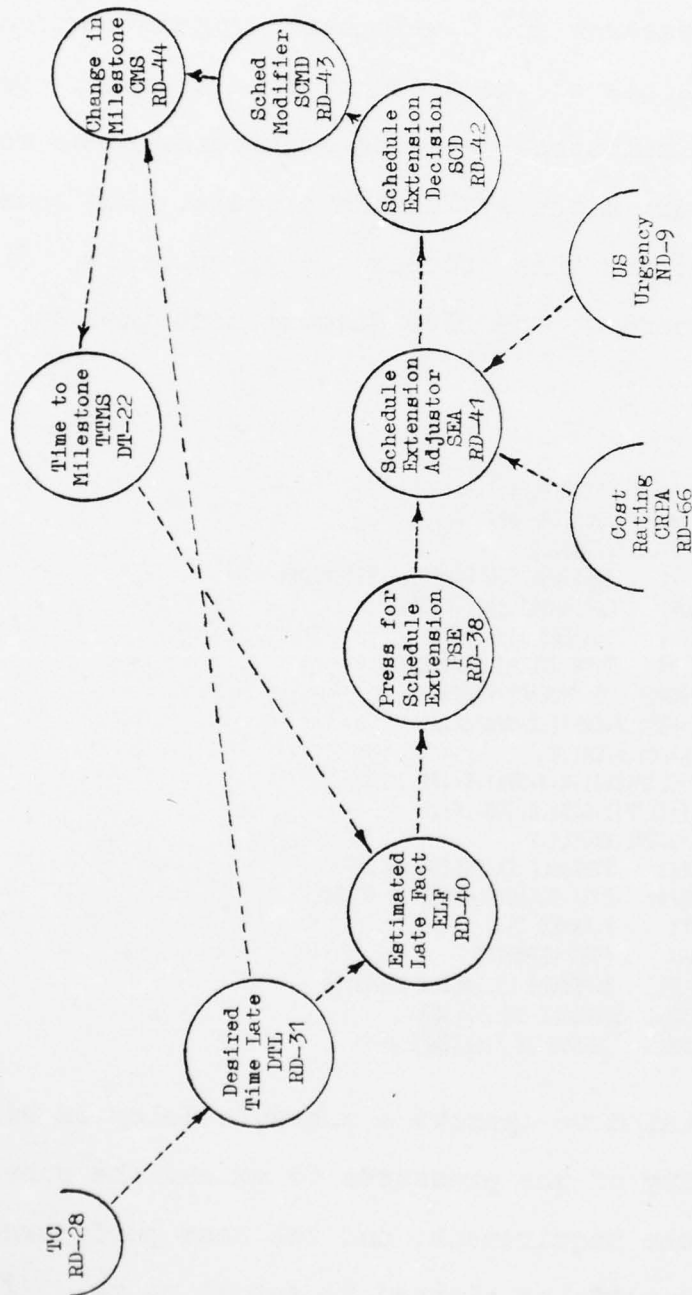


Figure 5-19
Weapon System Development--Schedule Extension

either the urgency is great or cost performance is very poor, there is a reluctance to approve schedule changes. Urgent requirements are pushed to meet a schedule, often sacrificing both performance and cost in order to obtain even a limited increase in capability.

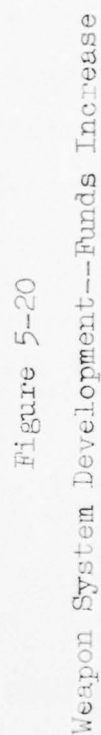
Changes in schedule do not necessarily mean that the total contract cost is changed. To illustrate the pressures for funding increases, the following equations are explained, which correspond to the flow diagram in Figure 5-20. The equations are:

```

A  FLF1.K=TABHL(FLFT,3*TWC1.K,0,10,1)
T  FLFT=0/0/.11/.22/.33/.45/.55/.66/.77/.88/1.0
NOTE  FLF1  FUNDS LIMIT FACTOR
A  TWC1.K=TTMS1.K*CRPA1.K
NOTE  TWC1  TIME WEIGHTED COST
NOTE  TTMS1  TIME TIL MILESTONE 1
NOTE  CRPA1  COST RATIO, PLANNED TO ACTUAL
A  PIF1.K=TABHL(PIFT,FLF1.K,0,1.4,2)
T  PIFT=1/.72/.57/.45/.38/.32/.28/.26/.25
NOTE  PIF1  PRESSURE FOR INCREASED FUNDS

```

The pressure results from the combined affect of both time and cost constraints on the research and development program. As the DSARC milestone draws near, the pressure increases if spending is ahead of schedule. The decision to increase costs is similar to the schedule change concept. The difference is that cost is the primary decisional criterion and performance/schedule aspects influence the decision. Also considered in the decision



are the urgency of the requirement for additional funds and the relative importance of the mission area which requires the funds. If a program is important or urgent, money restrictions are relaxed by the desire to continue the program to improve mission area capability. The last consideration is the funds available from other programs. If the contract cost is increased, amendments must be made and the appropriate financial transfers accomplished. The equations for this decision and result are:

```

A  ITAF1.K=FA1.K*PIF1.K*PRAP1.K*USURGF.K*MAIMPF
NOTE  ITAF1  INCLINATION TO APPROVE FUNDS
NOTE  PIF1   PRESSURE FOR INCREASED FUNDS
NOTE  PRAP1  PROGRESS RATIO, ACTUAL TO PLANNED
NOTE  MAIMPF MISSION AREA IMPORTANCE FACTOR
A  FID1.K=TABHL(FIDT,ITAF1.K,.8,2.0,.2)
T  FIDT=.0/.375/.62/.75/.86/.92/.96/.97
NOTE  FID1   FUNDS INCREASE DECISION
A  CPC1.K=FID1.K*ECC1.K
NOTE  CPC1   CHANGE IN PLANNED COST
NOTE  FID1   FUNDS INCREASE DECISION
A  ECC1.K=CLIP(ICR1.K,0,ICR1.K,0)*(TSMS0.K+TTMS1.K)/PTCR
A  ICR1.K=1-1/CRPA1.K
NOTE  ECC1   ESTIMATED CHANGE IN COST
NOTE  CRPA1  COST RATIO, PLANNED TO ACTUAL
NOTE  TSMS0  TIME SINCE MILESTONE 0
NOTE  TTMS1  TIME TIL MILESTONE 1
NOTE  PTCR   PROGRESS TO COST RATIO
NOTE  ICR    INCREASE IN COST RATE
A  FA1.K=TABHL(FAT,FAF1.K,.4,.05)
T  FAT=.0/.55/.375/.25/.1/.05/.02/.001/.0
NOTE  FA1    FUNDS AVAILABILITY
NOTE  FAF1   FUNDS AVAILABILITY FACTOR
A  FAF1.K=ECC1.K/RDA.K(2)
NOTE  FAF1   FUNDS AVAILABILITY FACTOR
NOTE  RDA(2) RESEARCH DOLLARS APPROPRIATED

```

The final concept expressed in this discussion of research and development management is product value. The

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value associated with a program becomes the decision criteria used in the DSARC process to approve or cancel a program. This measure is also used in the budgetary process to determine DOD funding and follow-on funding for the specified program. The flow diagram portrayed in Figure 5-21 depicts the structural aspects of this decision. This diagram represents the mathematical equations given below.

```

L   $PV1.K = PV1.J + DT * (PVR1.JK - PVTR1.JK)$ 
R   $PVR1.KL = PPVS1.K * PVA1.K$ 
A   $PPVS1.K = SMOOTH(PP1.K, PPD)$ 
NOTE  PV1    PRODUCT VALUE
NOTE  PVR1   PRODUCT VALUE RATE
NOTE  PVTR1  PRODUCT VALUE TRANSFER RATE
R   $PVR1.KL = PPVS1.K * PVA1.K$ 
NOTE  PPVS1  PLANNED PRODUCT VALUE (SMOOTHED)
A   $PPVS1.K = SMOOTH(PP1.K, PPD)$ 
NOTE  PP1    PLANNED PROGRESS
NOTE  PPD    PLANNED PROGRESS DELAY
A   $PVA1.K = PRAP1.K * CRPA1.K$ 
A   $PRAP1.K = PAP1.K / PP1.K$ 
NOTE  PVA1   PRODUCT VALUE ADJUSTOR
NOTE  PRAP1  PROGRESS RATIO, ACTUAL TO PLANNED
NOTE  CRPA1  COST RATIO, PLANNED TO ACTUAL
NOTE  PAP1   PERCEIVED ACTUAL PROGRESS
A   $CRPA1.K = PC1.K / CR1.K$ 
NOTE  CRPA1  COST RATIO, PLANNED TO ACTUAL
NOTE  PC1    PLANNED COST
NOTE  CR1    COST REPORTED

```

The level of product value is based on the perceived cost and progress performance which result from on-going research and development efforts. If either costs are greater than planned or actual progress is less than expected, the rate of increase in product value is diminished. When a milestone decision is required, the past performance of the program is evaluated and the decision

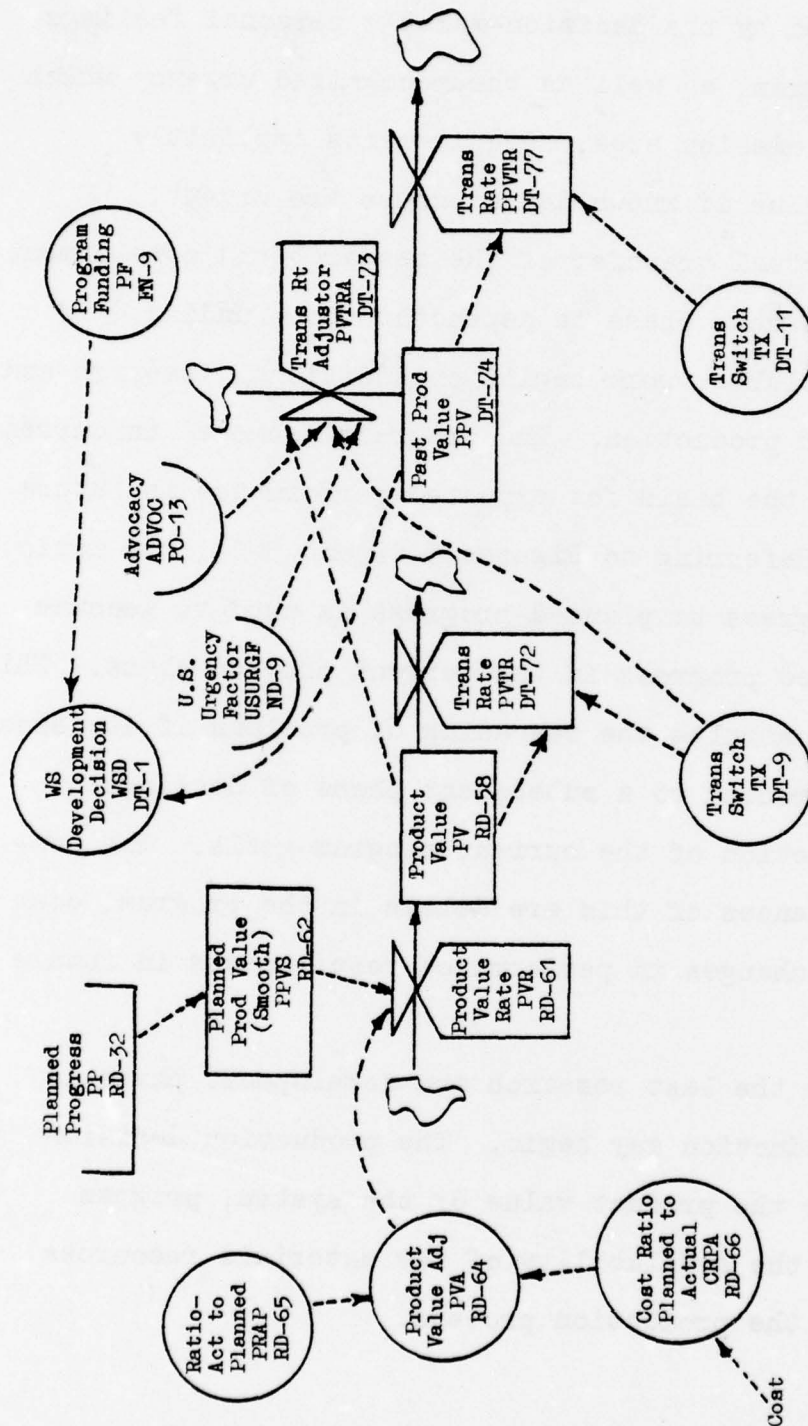


Figure 5-21
Weapon System Development--Product Value

is made to cancel or continue the program. This decision is also influenced by the decision-maker's personal feelings about the program, as well as the recognized urgency which exists in the mission area. Requirements implicitly increase in value if known deficiencies are urgent.

The actual transfer of the research and development process to the next phase is dependent upon funding. If funds are available, work begins on additional research and development or production. The progress achieved in current phase becomes the basis for expected performance in future activities. Referring to Figures 5-12 and 5-14, the ratio of actual progress to planned progress is used to measure the anticipated progress in the current project phase. This structure illustrates the cascading of problems if decisions are made to proceed to a subsequent phase of development without completion of the current program goals. The possible consequences of this are delays in the program, cost overruns, or changes in performance requirements in future periods.

After the last research and development phase is complete, production may begin. The production decision must consider the product value of the system, program funding, and the availability of raw materials resources required for the production process.

Resources Sector

The flow of worldwide resources is depicted in the flow diagram contained in Figure 5-22. Worldwide resources are an aggregate measure of all the raw materials available for consumption. In his world policy model, Forrester (25) used the number of years supply remaining, if current per capita consumption continued. Consumption was based on expected growth, represented by changes in the gross national product. Borrowing from this concept, the following system equations were developed for the resources sector.

```
L  TOTRES.K=TOTRES.J+DT*(DISCOV.JK-TRUSE.JK)
R  DISCOV.KL=DISCOF.K*TOTRES.K
R  TRUSE.KL=GROWTH.K*TOTRES.K
NOTE  DISCOV  DISCOVERY RATE
NOTE  TRUSE   TOTAL RESOURCE USE RATE
NOTE  DISCOF  DISCOVERY FRACTION
NOTE  GROWTH  GROWTH RATE
```

The level of total world resources (TOTRES) is increased by discoveries of new resources and increased extraction rates of existing resources. Consumption of resources decreases the level. The discovery and use rates are both expressed as a percent of the total resources available.

The discovery of resources fraction is a function of the amount of pressure to search for new resources or

increase extraction of existing resources. This pressure results from declining levels of available resources. As the search for resources increases, the number of resources discovered increases over time. The next group of equations apply to the discovery of resources.

```
A DISCOF.K=TABHL(DISCOT,SEARCH,K,0,1,.02)
T DISCOT=0/.02/.06/.08/.09/.1
A SEARCH.K=SMOOTH(SEARC,K,30)
T SEARCT=1/.9/.8/.55/.3/.15
A SEARC.K=TABHL(SEARCT,TOTRES,K,0,100,20)
NOTE DISCOF DISCOVERY FRACTION
NOTE SEARCH SEARCH FOR RESOURCES(SMOOTHED)
NOTE SEARC SEARCH FOR RESOURCES
NOTE TOTRES TOTAL RESOURCES
```

Further equations apply the resources allocated for defense to the production of weapons for the allies and the enemy. The percentage of resources available for defense production is a function of the total resources available to each country. As noted in Chapter 4, Smith (59) explained the willingness of the Soviet Union to withhold resources from its populace in order to further defense production. In the context of this model, therefore, the enemy sector is considered to have no real constraint due to resources on defense production.

```
A RADPP.K=TABHL(RADPPT,TOTRES,K,0,100,10)
T RADPPT=0/.1/.25/.4/.35/.32/.3/.28/.27/.26/.25
NOTE RADPP RESOURCES AVAILABLE % FOR DEFENSE PRODUCTION
NOTE TOTRES TOTAL RESOURCES
A RAADP.K=TOTRES.K*RADPP.K*AALLOC
NOTE RADPP RESOURCES AVAILABLE FOR ALLIED DEFENSE PRODUCTION
NOTE AALLOC ALLIED ALLOCATION PERCENT
```


A $RAEDP.K = TOTRES.K * RADPP.K * EALLOC$
 NOTE RAEDP RESOURCES AVAILABLE FOR ENEMY DEFENSE PRODUCTION
 NOTE EALLOC ENEMY ALLOCATION PERCENT

The percentage of resources available for defense production is a function of the total resources available. As the level of resources declines, a greater percent of total resources is allocated to defense production in order to protect resources that are available. This behavior occurs until resources become so scarce that defense production is infeasible. The resources available for defense production are determined by the relative amounts of total resources which are allocated to the allies and the enemy.

The flow diagram in Figure 5-23 represents the U.S. resource sector. The U.S. is estimated to use approximately one-third of the total world resources (45). The equations which apply to U.S. resources are noted here.

L $USRES.K = USRES.J + DT * (RAUS.JK - RDMUS.JK)$
 R $RAUS.KL = DISCOV.JK * ALLOCF$
 R $RDMUS.KL = (GROWTH.K - (EFFF.K / 100)) * USRES.K$
 NOTE USRES US RESOURCES
 NOTE RAUS RESOURCES ALLOCATED TO US
 NOTE RDMUS RESOURCES DEMANDED (USEX) BY US
 NOTE DISCOV DISCOVERY FRACTION
 NOTE GROWTH GROWTH RATE
 NOTE EFFF EFFICIENCY FACTOR
 NOTE ALLOCF US ALLOCATION FACTOR

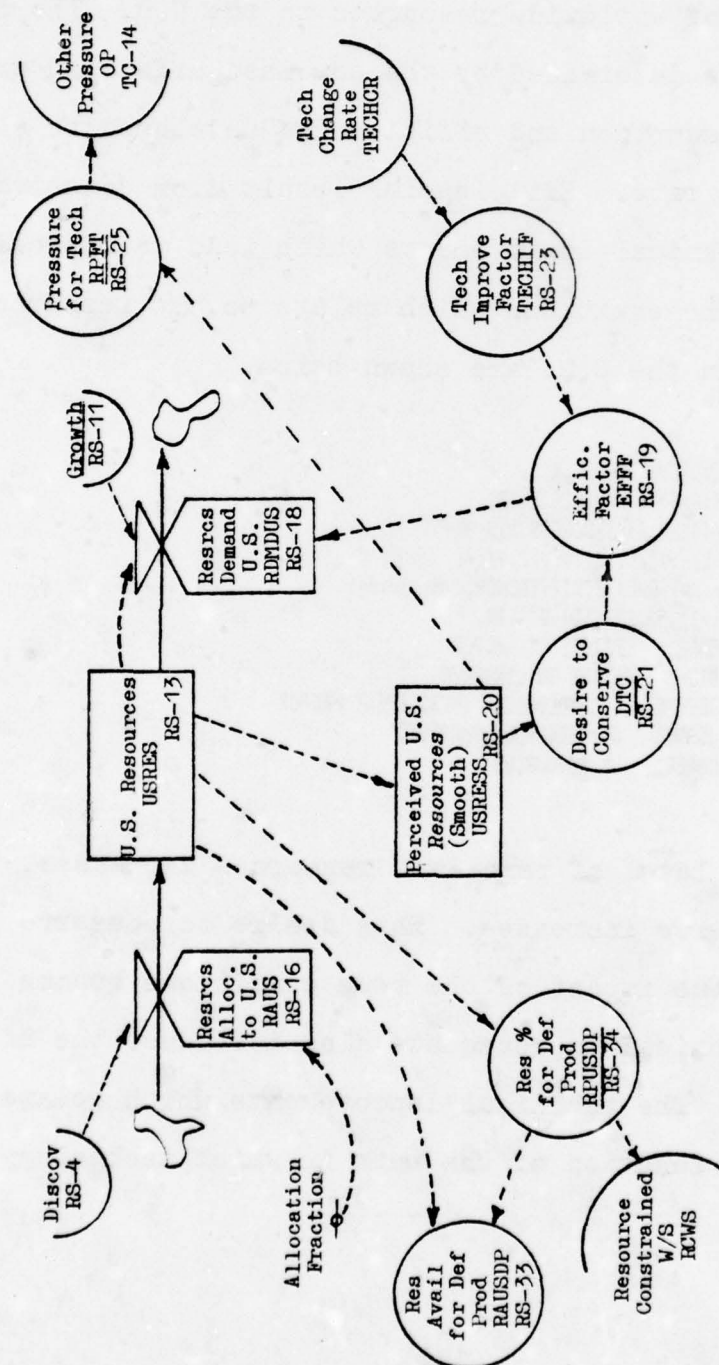


Figure 5-23
Resources Sector--U.S.

This equation set is similar to the levels and rates for total resources. The U.S. resources level is increased by allocations of worldwide resources to the U.S. The demand for resources is determined by the combined effect of growth in resource consumption and efficiencies developed to slow the consumption rate. Efficiencies result from conservation efforts and technical improvements which lead to reduced consumption. The equations which relate to the resource consumption rate in the U.S. are shown below.

```

A  EFFF.K=DTC.K+TECHIF.K
A  USRESS.K=SMOOTH(USRES.K,10)
A  DTC.K=TABHL(DTCT,USRESS.K,0,35,5)
T  DTCT=-2/- .75/- .15/.4/.7/.9/1/1
A  TECHIF.K=TABHL(TECHIT,TECHCR.K,0,.2,.04)
T  TECHIT=1/.5/.25/.15/.07/.04
NOTE  EFFF  EFFICIENCY FACTOR
NOTE  DTC   DESIRE TO CONSERVE
NOTE  TECHIF TECHNOLOGICAL IMPROVEMENT FACTOR
NOTE  USRESS US RESOURCES(SMOOTHED)
NOTE  USRES  US RESOURCES

```

As the level of perceived resources decreases, the desire to conserve increases. This desire to conserve is delayed until the impact of the true conditions become apparent. Technical improvements also influence the efficiency factor. The technical improvements which relate to resources is a function of the rate in which technology changes.

In addition to influences within the sector, the state of resources also affects other sectors as shown below. As the perceived U.S. resources decrease, pressure is created for new resource-saving technologies.

In addition to effects of technology demands, the percentage of resources available for U.S. defense production may become a constraint in the production process if the production plan exceeds the resources that are available.

```

A  RPFT.K=TABHL(RPFTT,USRESS.K,0,100,10)
T  RPFTT=1/.8/.7/.6/.6/.45/.4/.37/.35
A  RAUSDP.K=USRES.K*RPUSDP.K
A  RPUSDP.K=TABHL(RPUSDT,USRES.K,0,35,5)
T  RPUSDT=.8/.2/.4/.3/.28/.27/.26/.25
NOTE  RPFT  RESOURCE PRESSURE FOR TECHNOLOGY
NOTE  USRESS  US RESOURCES(SMOOTHED)
NOTE  RAUSDP  RESOURCES ALLOWED FOR US DEFENSE PRODUCTION
NOTE  RPUSDP  RESOURCE PERCENT FOR US DEFENSE PRODUCTION
NOTE  USRES  US RESOURCES

```

Production Sector

This sector will address the transformation process which integrates the various production inputs, such as resources, research and development knowledge, production plans, and funding, to produce weapon systems for U.S. operations. Many of the concepts which are included in the model of the production process are similar to those discussed for the research and development process. The flow of weapon systems and the information network which

influences flow in the production process are depicted in Figure 5-24. The first set of equations which apply to the production process are given below.

```

L  WSP.K=WSP.J+DT*(WSPIR.JK-WSPR.JK)
R  WSPIR.KL=MIN(PGM4.K,RCWS.K)
R  WSPR.KL=DELAY3(WSPIR.JK,PRODT.K)
A  PGM4.K=TABLE(PGM1T,SCHEDP.K,0,1,.0833)*WSD4.K*12+DCP4.K/
X  (TSMS3.K+TTPCC.K)
NOTE  WSP  WEAPON SYSTEMS IN PRODUCTION
NOTE  WSPIR  WEAPON SYSTEM PRODUCTION INPUT RATE
NOTE  WSPR  WEAPON SYSTEM PRODUCTION RATE
NOTE  PGM4  PROGRAM
NOTE  WSD4  WEAPON SYSTEM DEVELOPMENT DECISION
NOTE  DCP4  DECISION COORDINATING POINT
NOTE  TSMS3  TIME SINCE MILESTONE 3
NOTE  TTPCC  TIME TO PRODUCTION COMPLETION
A  SCHEDP.K=TSMS3.K/(TSMS3.K+TTPCC.K)
A  RCWS.K=RAUSDP.K*WSRCF
A  PRODT.K=APRODT.K+PRODTA.K
NOTE  SCHEDP  PRODUCTION SCHEDULE
NOTE  RCWS  RESOURCE CONSTRAINT ON WEAPON SYSTEMS
NOTE  RAUSDP  RESOURCES AVAILABLE FOR DEFENSE PRODUCTION
NOTE  WSRCF  WEAPON SYSTEM TO RESOURCES CONVERSION FACTOR
NOTE  PRODT  PRODUCTION TIME

```

The level of weapon systems in the production process is determined by two rates. The input to production is determined by the production plan. This plan is similar to plans for research and development except that the measurement is in weapon systems instead of progress. The plan may be adjusted if resource availability requires. The rate of output from production is a function of the input of weapons into the production process and the amount of time required to produce each weapon system. If the production flow time is reduced, the total number of systems in production is decreased. By adjusting the flow time, the

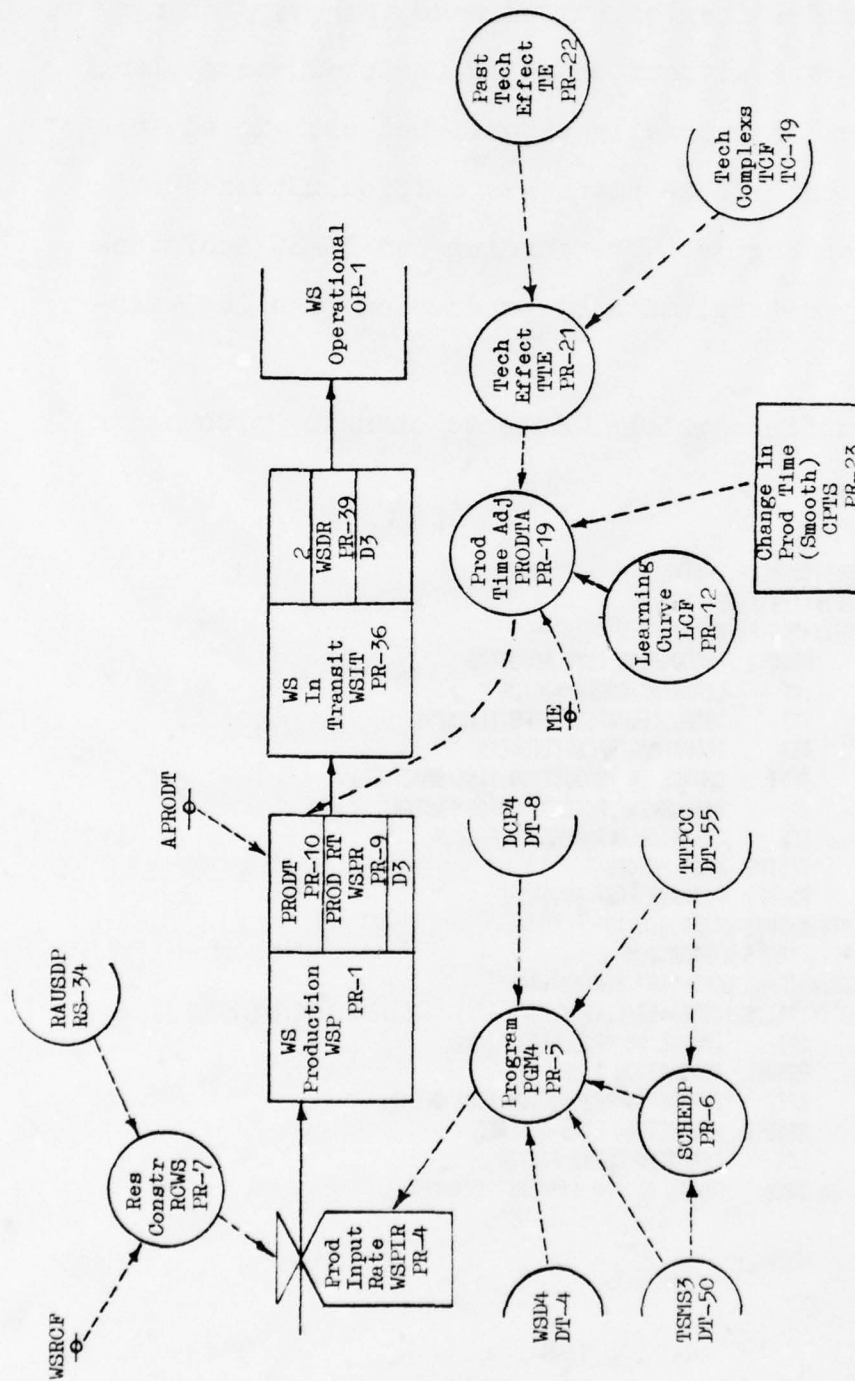


Figure 5-24
Production Sector--Production Process

number of resources contained in the production pipeline is changed. This is useful to management of DOD acquisitions because it provides flexibility to make temporary changes to the production rate without changing the production plan. Production plans are normally established well in advance of actual production. These plans are difficult to adjust after production begins. The funding and DSARC decisions are the primary determinants of production plan implementation.

The equations which relate to changing production flow times are:

```

A  PRODTA.K=LCF.K*(TTE.K*ME4*CPTS.K)
A  TTE.K=TE4.K*ME4/TCF.K
A  TE4.K=PASTP3.K/PSTPP3.K
NOTE  PRODTA  PRODUCTION TIME ADJUSTOR
NOTE  LCF     LEARNING CURVE FACTOR
NOTE  TTE     TOTAL TECHNICAL EFFECTIVENESS
NOTE  TE4     TECHNICAL EFFECTIVENESS
NOTE  CPTS    CHANGE IN PRODUCTION TIME(SMOOTHED)
NOTE  ME4     MANAGEMENT EFFECTIVENESS FACTOR
NOTE  TCF     TECHNICAL COMPLEXITY FACTOR
NOTE  PASTP3  PAST PROGRESS
NOTE  PSTPP3  PLANNED PAST PROGRESS
A  CPTS.K=SMOOTH(CPT.K,CPTD)
A  CPT.K=PRODT.K-PRODTD.K
A  LCF.K=TABHL(LCFT,TWSP.K,0,520,40)
T  LCFT=1/1.15/1.35/1.57/1.69/1.78/1.87/1.96/2.02/2.11/2.2/2.2/2.2
NOTE  CPT     CHANGE IN PRODUCTION TIME
NOTE  PRODT   PRODUCTION TIME
NOTE  CPTD    CHANGE IN PRODUCTION TIME DELAY
NOTE  PRODTD  PRODUCTION TIME DESIRED
NOTE  LCF     LEARNING CURVE FACTOR
NOTE  TWSP    TOTAL WEAPON SYSTEMS PRODUCED

```

As noted from the equations, four elements affect the adjustment to flow time. The first three elements are similar to those discussed in research and development. They include: technical effectiveness, managerial effectiveness, and changes in production due to evaluation of production progress. The fourth element which affects the adjustments to production times is the learning curve. As more systems are produced, the production times are decreased due to the efficiencies which result from learning the production process. The flow diagram contained in Figure 5-25 depicts the accumulation of production know-how which determines the relative effect of the learning curve. The following equation set mathematically represents the accumulation of production knowledge.

```

A  RWSP.K=NWSP.K-TWSP.K
A  WSPRR.K(P)=RWSP.K/RTTPCC.K(P)
NOTE  RWSP  REMAINING WEAPON SYSTEMS TO PRODUCE
NOTE  NWSP  NUMBER OF WEAPON SYSTEMS TO PRODUCE
NOTE  WSPRR  WEAPON SYSTEM PRODUCTION RATE REQUIRED
NOTE  RTTPCC  REMAINING TIME TO PRODUCTION COMPLETION
L  TWSP.K=TWSP.J+DT*(WSPR.JK-LCRR.JK)
R  LCRR.KL=TX4.K*TWSP.K
NOTE  TWSP  TOTAL WEAPON SYSTEMS TO PRODUCE
NOTE  WSPR  WEAPON SYSTEM PRODUCTION RATE
NOTE  LCRR  LEARNING CURVE RELEASE RATE

```

The total number of weapon systems produced becomes the comparison device to evaluate production progress. As the actual number of weapon systems produced deviates from

from production plans, management initiates changes to the production process using the same type of decisional phase described in the research and development section. The result of the cost and schedule trade-offs determines the actual changes made to the production process via changes in the flow time.

The remainder of the model of the production process is constructed along the same lines as the research and development phases. The flow diagrams and equations development for cost reporting and cost/schedule changes will not be discussed to avoid repetition. Also, the concept of product value was omitted from this portion of the model since further decisions concerning the program are made by evaluating the actual performance in the operational environment.

As systems are produced, they are shipped to the operational commands. The weapon systems in transit and the subsequent delivery rate is a function of the production rate and the time in transit. This is developed into the following equations.

```

L  WSIT.K=WSIT.J+DT*(WSPR.JK-WSDR.JK)
R  WSDR.KL=DELAY3(WSPR.JK;2)
NOTE  WSIT  WEAPON SYSTEMS IN TRANSIT
NOTE  WSPR  WEAPON SYSTEMS PRODUCTION RATE
NOTE  WSDR  WEAPON SYSTEMS DELIVERY RATE

```


The flow of weapons to the operational commands provides increased capability which, in turn, relieves the pressure for weapon system production. The next section of this chapter will discuss the effects of weapon system inventories as they are used in the operational environment.

U.S. Operations

The flow of inventory into the operational environment is depicted in the diagram contained in Figure 5-26. As new systems are delivered to the operational commands, the inventory is used to accomplish the mission requirements established by the operating plans for each base. Two system states are represented in the model. Operational weapon systems are able to accomplish their assigned missions. Non-operational weapon systems cannot accomplish their missions due to system failures, scheduled maintenance, supply problems, or personnel support problems. The final inventory state is implied by the retirement rate. The retired inventory encompasses weapons delivered to storage and those systems lost through attrition. The following equations provide the basis for discussion about the state of U.S. forces.

```

L  WSO.K=WSO.J+DT*(WSMR.JK+WSDR.JK-WSSDR.JK-WSRR.JK)
L  WSN.K=WSN.J+DT*(WSSDR.JK-WSMR.JK)
R  WSSDR.KL=USE.K/MTBF.K
R  WSMR.KL=WSORP.K*OSF.K

```

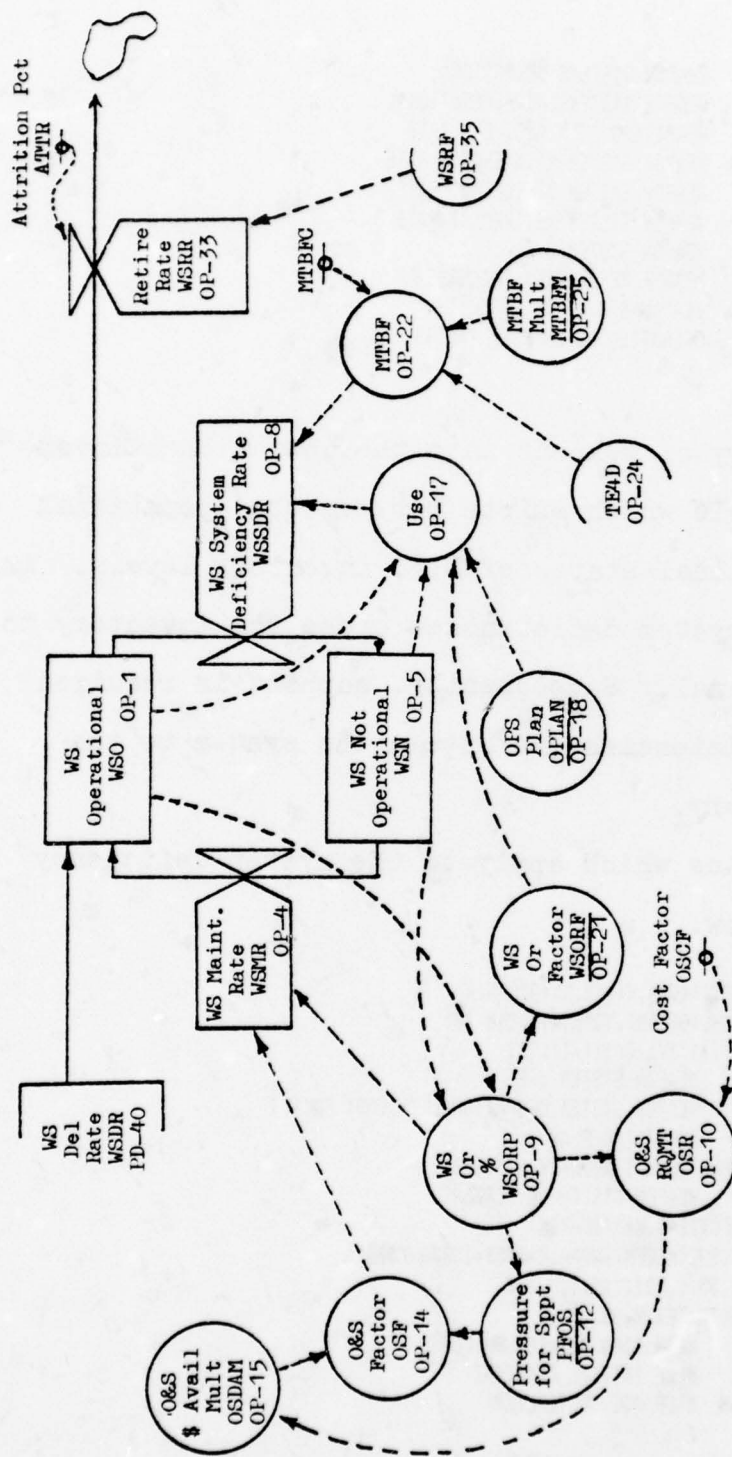


Figure 5-26
U.S. Operations Sector---Inventory

NOTE	WSO	WEAPON SYSTEMS OPERATIONAL
NOTE	WSN	WEAPON SYSTEMS NON-OPERATIONAL
NOTE	WSDR	WEAPON SYSTEM DELIVERY RATE
NOTE	WSMR	WEAPON SYSTEM MAINTENANCE RATE
NOTE	WSSDR	WEAPON SYSTEM DEFICIENCY RATE
NOTE	WSRR	WEAPON SYSTEM RETIREMENT RATE
NOTE	USE	WEAPON SYSTEM USE
NOTE	MTBF	MEAN TIME BETWEEN FAILURES
NOTE	WSORP	WEAPON SYSTEM OR PERCENT
NOTE	OSF	OPERATING NO SUPPORT FACTOR

The delivery of weapons into the operational inventory begins the cycle which exists between the operational and the non-operational states of U.S. inventory levels. As weapons are used, system deficiencies cause the inventory to become non-operational. Subsequently, support is required to correct the deficiencies and return the system to the operational inventory.

The equations which apply to the system deficiency rate are given below.

A	USE.K=WSORF.K*(WSO.K+WSN.K)*OPLAN.K
A	OPLAN.K=TABHL(OPLANT,TIME.K,0,240,20)
T	OPLANT=1/1/1/1/1/1.2/1/1/1/1.9/1
NOTE	USE WEAPON SYSTEM USE
NOTE	WSORF WEAPON SYSTEM OPERATIONALLY READY FACTOR
NOTE	OPLAN OPERATING PLAN
A	WSORF.K=TABHL(WSORFT,WSORP.K,0,50,10)
NOTE	WSORP WEAPON SYSTEM OR PERCENT
A	MTBF.K=MTBFC*TE4D.K*MTBFAM.K
A	MTBFAM.K=TABHL(MTBFMT,WSAA.K,5000,15000,2000)
T	MTBFMT=1/1.05/1.13/1.25/1.6/1.9
A	TE4D.K=SMOOTH(TE4.K,10)
NOTE	MTBF MEAN TIME BETWEEN FAILURES
NOTE	MTBFC MTBF INITIAL CONSTANT
NOTE	MTBFAM MTBF AGE MULTIPLIER

NOTE	TE4D	TECHNICAL EFFECTIVENESS DESIGNED(SMOOTHED)
NOTE	TE4	TECHNICAL EFFECTIVENESS DESIGNED
NOTE	WSAA	WEAPON SYSTEM AVERAGE AGE

As use increases, the number of system deficiencies also increases. The actual use rate is determined by the flying hours or mission programs and the constraints that exist from the current inventory. As more and more weapons become non-operational, the operating plan cannot be fully accomplished. The other determinant of system deficiencies is the inherent system reliability. This is expressed in terms of mean time between failures (MTBF). In this model, an aggregate measure is used to show the ratio of weapon system failures to the operating program period. The failure rate is influenced by the technical effectiveness achieved in the production process, equipment aging, and equipment enhancements due to modification of existing systems.

The activities and decisions affecting the maintenance rate are represented by the equations:

A	$WSORP.K = WSO.K / (WSN.K + WSO.K)$	
NOTE	WSORP	WEAPON SYSTEMS OPERATIONAL READY PERCENT
NOTE	WSO	WEAPON SYSTEMS OPERATIONAL
NOTE	WSN	WEAPON SYSTEM NON-OPERATIONAL
A	$OSR.K = WSORP.K * OSCF$	
NOTE	OSR	O&S REQUIRED
NOTE	OSCF	O&S COST FACTOR
A	$PFOS.K = TABHL(PFOS, WSORP.K, 0, 1, 2)$	
T	$PFOS = 1/1/1/1.15/1.82/2.68$	
NOTE	PFOS	PRESSURE FOR O&S


```

A  OSF.K=OSDAM.K*PFOS.K
NOTE  OSF  O&S FACTOR
NOTE  OSDAM  O&S DOLLAR AVAILABILITY MULTIPLIER
NOTE  OSA  O&S AVAILABLE
A  OSDAM.K=TABLE(OSDAMT,OSR.K/OSA.K(1),0,2,.2)
T  OSDAMT=1/.78/.9/.82/.7/.52/.39/.29/.26/.24/.22

```

The percent of the total weapon systems operational is used to determine the relative degree of pressure that is placed on the logistics system to provide support. As more systems become non-operational, pressure is increased. This pressure acts to increase the maintenance rate; however, funds may limit the degree to which maintenance can support the increased demands.

The rate that weapons are removed from the inventory is determined by the number of weapon system attritions and the planned rate of retirement. The equations which represent the decision process which supports the actions to remove weapon systems from the U.S. inventory as depicted in Figure 5-27 are shown below:

```

L  AWSA.K=AWSA.J+DT*(WSAR.JK-WSARR.JK)
R  WSAR.KL=USE.K
R  WSARR.KL=(MODF.K*AWSA.K)+WSAA.K*WSRR.JK
NOTE  AWSA  ACCUMULATED WEAPON SYSTEM AGE
NOTE  WSAR  WEAPON SYSTEM AGE RATE
NOTE  WSARR  WEAPON SYSTEM AGE RESTORATION & RETIREMENT RATE
NOTE  USE  WEAPON SYSTEM USE
NOTE  MODF  MODIFICATION FACTOR

```

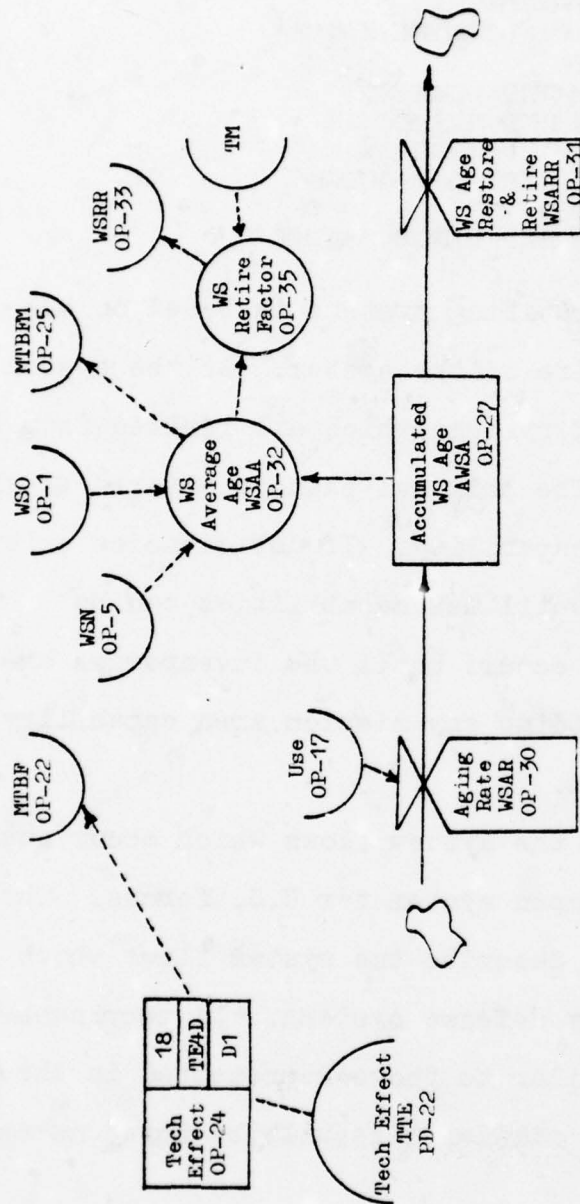



Figure 5-27
U.S. Operations Sector--Reliability and Aging

```

A  WSAA.K=AWSA.K/(WSU.K+WSN.K)
R  WSRR.KL=MIN(1,WSO.K*(ATTR+WSRF.K))
A  WSRF.K=TABHL(WSRFT,WSAA.K,2500,10000,2500)*TM.K
T  WSRFT=0/.33/.66/1.00
NOTE  WSAA  WEAPON SYSTEM AVERAGE AGE
NOTE  WSRR  WEAPON SYSTEM RETIREMENT RATE
NOTE  WSO   WEAPON SYSTEMS OPERATIONAL
NOTE  WSN   WEAPON SYSTEMS NON-OPERATIONAL
NOTE  ATTR  ATTRITION FACTOR
NOTE  WSRF  WEAPON SYSTEM RETIREMENT FRACTION

```

The original plan for retiring systems is based on the expected operational life of the system. As the system ages, the percentage of systems which are retired from the inventory increases. The original plan is altered by the actual needs for U.S. capability. If deficiencies exist, retirement is delayed until new capabilities can be developed. This delay occurs until the inventories are no longer capable of providing any mission area capability or all systems are retired.

This completes the system flows which occur over the life cycle of a weapon system for U.S. forces. The next two sections will describe the system flows which apply to the allied and enemy defense systems. In many cases the model concepts are similar to those represented in the U.S. defense system. These similarities will be noted as appropriate.

Allied Sector

The Allied Sector contains the flow of weapons and information associated with weapon system decisions. The

basic structure of the inventory flow is similar to the U.S. Operations Sector. In addition to this structure, the force aging, capability and threat assessment, are also similar. The unique portions of this sector involve allied evaluations of productive capacity and desires to produce or purchase weapons. This decision, in part, affects the political, military, and economic ties with the U.S. and determines the allied demands for acquisition in the U.S.

The flow diagram contained in Figure 5-28 depicts the flow of inventory through the allied defense system. As noted, the structure is very similar to the U.S. operations. The only difference is that purchase of inventory from the U.S. is also represented in the allied defense system. The equations which apply to this structure are:

```

L  AWSP.K=AWSP.J+(DT)*(AWSPR.JK-AWSDR.JK)
R  AWSPR.KL=FSHIFT(APLAN.K)
A  ADEL.R.K=24/AURCF.K
R  AWSDR.KL=DELAY3(AWSPR.JK, ADEL.R.K)
NOTE  AWSP  ALLIED WEAPON SYSTEMS IN PRODUCTION
NOTE  AWSPR  ALLIED WEAPON SYSTEMS PRODUCTION RATE
NOTE  APLAN  ALLIED PLANNED PRODUCTION
NOTE  ADEL.R  ALLIED DELAY RATE IN PRODUCTION
NOTE  AURCF  ALLIED URGENCY FACTOR
L  AWSO.K=AWSO.J+DT*(AWSDR.JK+AWSMR.JK-AWSUR.JK+AFMSDR.JK)
NOTE  AWSO  ALLIED WEAPON SYSTEMS OPERATIONAL
NOTE  AWSDR  ALLIED WEAPON SYSTEMS DELIVERY RATE
NOTE  AWSMR  ALLIED WEAPON SYSTEMS MAINTENANCE RATE
NOTE  AWSUR  ALLIED WEAPON SYSTEMS USE RATE
NOTE  AFMSDR  ALLIED FOREIGN MILITARY SALES DELIVERY RATE

```

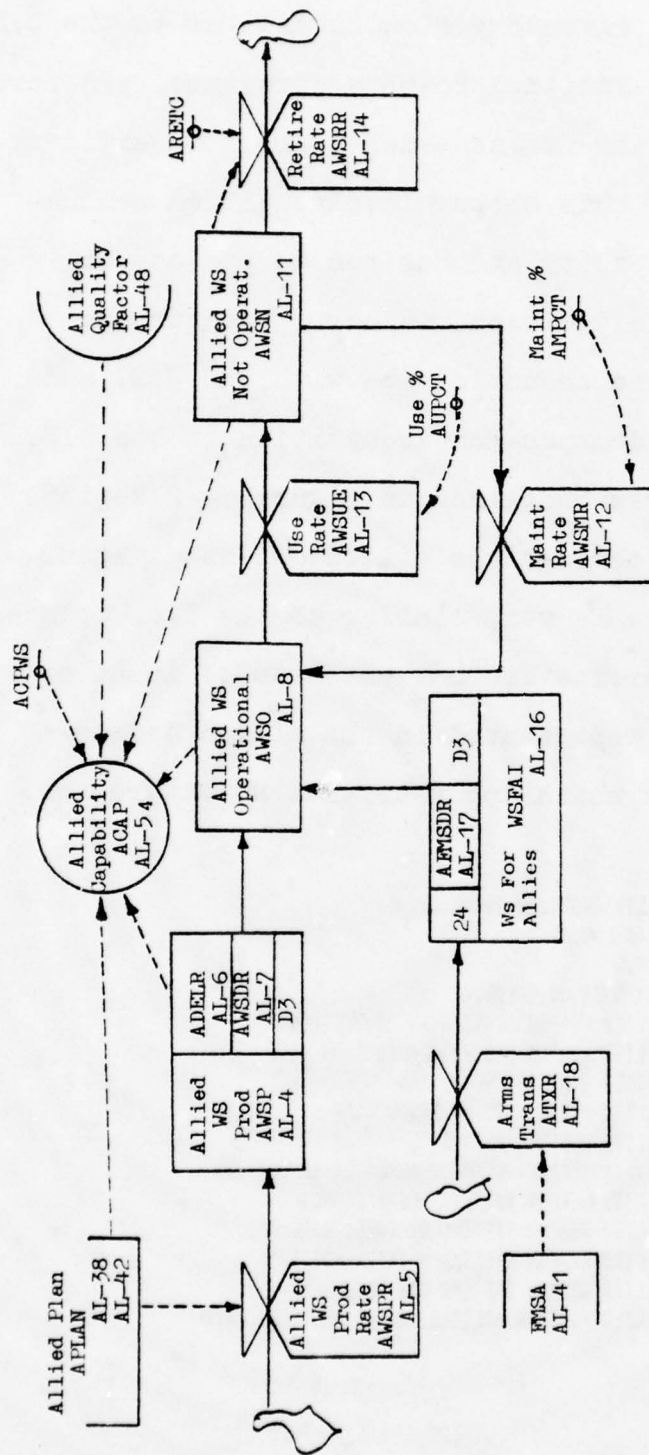


Figure 5-28
Allied Sector---Inventory

```

L  AWSN.K=AWSN.J*(BT)(AWSUR.JK-AWSMR.JK-AWSRR.JK)
R  AWSMR.KL=AWSN.K*AMPCT
R  AWSUR.KL=AWSO.K*AUPCT
R  AWSRR.KL=ARETC*AWSN.K
NOTE  AWSN  ALLIED WEAPON SYSTEMS NON-OPERATIONAL
NOTE  AWSRR  ALLIED WEAPON SYSTEMS RETIREMENT RATE
NOTE  AMPCT  ALLIED PERCENTAGE OF WEAPONS REPAIRED
NOTE  AUPCT  ALLIED PERCENTAGE OF WEAPONS USED
NOTE  ARETC  ALLIED RETIREMENT CONSTANT
L  WSFAI.K=WSFAI.J+DT*(ATXR.JK-AFMSDR.JK)
R  AFMSDR.KL=DELAY3(ATXR.JK,24)
R  ATXR.KL=FMSIFT(FMSA.K)
NOTE  WSFAI  WEAPON SYSTEMS FOR ALLIED INVENTORIES
NOTE  ATXR  ALLIED TRANSFER RATE
NOTE  FMSA  FOREIGN MILITARY SALES AGREEMENTS
NOTE  ARETC  ALLIED RETIREMENT CONSTANT

```

U.S. transfer of arms to allied nations is determined by the level of approved foreign military sales agreements. Systems are scheduled for delivery to the allies after a delay to facilitate administrative and procurement activities which must occur to prepare the weapon systems order. The combined effect of allied inventories leads to capability. This capability includes both quantitative and qualitative features as noted in the Need Sector for U.S. defense.

In the model, the qualitative features which relate to allied inventories are represented as a function of the degree of standardization between U.S. and allied inventory and the average age of the allied force. The flow diagram contained in Figure 5-29 depicts the determination of aging and standardization. The following equations correspond to the standardization aspect of inventory quality:



Figure 5-29

Allied Sector--Aging and Standardization

```

A AGEF.K=TABHL(AGFT,AAGE,K/12,0,10,1)
T AGFT=1/1/1/1/1/1.25/1.75/2.5/3.25/4.15/6.0
NOTE AGEF AGE FACTOR
NOTE AAGE AVERAGE AGE
NOTE
A STDF.K=TABHL(STDFT,APSW,K,0,1,1)
T STDFT=2/1.75/1/.85/.65/.43/.30/.23/.17/.12/.05
NOTE STDF STANDARDIZATION FACTOR
A AQF.K(MO)=TABHL(AQUAL,T(MO)*AGEF.K/STDF.K,0,120,12)
T AQUAL=1.0/.99/.99/.98/.95/.85/.7/.55/.35/.25/.1
NOTE AQF ALLIED QUALITY FACTOR
NOTE T TIME
A APSWS.K=ASTINV.K/(AWSO.K+AWSN.K)
L ASTINV.K=ASTINV.J+DT*(ASTR.JK)
R ASTR.KL=FMSA.K(1)+SWITCH(0,AWSR.JK,COFAC.K)
A COFAC.K=ACOPR.K*USCOPA.K
NOTE APSWS ALLIED PERCENTAGE OF STANDARDIZED WEAPON SYSTEMS
NOTE ASTINV ALLIED STANDARDIZED INVENTORY
NOTE AWSO ALLIED WEAPON SYSTEMS OPERATIONAL
NOTE AWSN ALLIED WEAPON SYSTEMS NON-OPERATIONAL
NOTE ASTR ALLIED STANDARDIZATION TRANSFER RATE
NOTE FMSA FOREIGN MILITARY SALES AGREEMENTS
NOTE AWSR ALLIED WEAPON SYSTEMS DELIVERY RATE
NOTE COFAC COPRODUCTION FACTOR
NOTE ACOPR ALLIED COPRODUCTION REQUEST
NOTE USCOPA US COPRODUCTION AGREEMENT

```

Standardization results from both foreign military sales and co-production agreements. As the number of allied systems common to U.S. forces increases, the overall quality factor is increased. This concept assumes that capability is enhanced as support increases. Standardized equipment enhances the logistics system's ability to respond to demands for equipment, supplies, and personnel to support mission requirement for both U.S. and allied forces. This is particularly important in wartime.

The age of the force also impacts the quality aspect of the allied inventory. The equations for this concept are:

```

N   FLTAGE=AAGE+WSO
L   FLTAGE,K=FLTAGE,J+DT*(AGER,JK)
R   AGER,KL=AWSO,K+AWSN,K-AWSRR,JK+AAGE,K+DISTK
NOTE   FLTAGE   COMBINED AGE OF ALLIED FLEET
NOTE   AWSO     ALLIED WEAPON SYSTEMS OPERATIONAL
NOTE   AGER     ALLIED AGE RATE
NOTE   AWSN     ALLIED WEAPON SYSTEMS NON-OPERATIONAL
NOTE   AWSRR    ALLIED WEAPON SYSTEMS RETIREMENT RATE
NOTE   DISTK    DISTRIBUTION CONSTANT
A   AAGE,K=FLTAGE,K/(AWSO,K+AWSN,K)
NOTE   AAGE     AVERAGE AGE OF ALLIED WEAPONS

```

The product of weapon system quantities and the related quality is the basis for determining allied capability. Capability is used to compare to threats in order to determine weapon system plans. The same concept as applied in the U.S. needs sector is used. In Figure 5-30 the threat assessment and planning activity are shown. The following equations correspond to the portion of the flow diagram which depicts deficiency identification.

```

A   ACAP,K(MO)=(AWSO,K+AWSN,K+AWSP,K+SUMV(APLAN,K(*),1,
X   T(MO))) * ACPWS * AQF,K(MO)
A   ADEF,K(MO)=MAX(ADIF,K(MO),0) * ADPCT,K
A   ADIF,K(MO)=ECAP,K(MO)-ACAP,K(MO)-USCAP,K(MO)
NOTE   ADEF     ALLIED DEFICIENCY
NOTE   ADIF     ALLIED DIFFERENCE IN CAPABILITY
NOTE   ADPCT    ALLIED PERCENTAGE OF DEFICIENCY
NOTE   ECAP     ENEMY CAPABILITY
NOTE   ACAP     ALLIED CAPABILITY
NOTE   USCAP    US CAPABILITY
A   AURCF,K=TABLE(EWGT,AURC,K/12,0,10,1)
A   AURC,K=URGENCY(ADEF,K)
NOTE   AURCF    ALLIED URGENCY FACTOR
NOTE   EWGT     URGENCY WEIGHTING TABLE
NOTE   AURC     ALLIED URGENCY--TIME TO FIRST DEFICIENCY

```



```

A  APTHR.K(MO)=(EINT.K-USINT.K)*ADEF.K(MO)
NOTE  APTHR  ALLIED PERCEIVED THREAT
NOTE  EINT   ENEMY INTENT TO USE FORCE
A  ADWSL.K(MO)=ADESWF*APTHR.K(MO)/ACPWS
NOTE  ADWSL  ALLIED DESIRED WEAPON SYSTEMS LEVEL
NOTE  ADESWF ALLIED DESIRE FOR WEAPONS FACTOR
NOTE  ACPWS  ALLIED CAPABILITY PER WEAPON SYSTEM

```

A portion of the total deficiency is allocated to the allies. The deficiency becomes the basis for threat and determines the sense of urgency which drives the weapon systems planning process.

As needs become urgent, the production plans are increased if production capacity is available. The planning process is accomplished in two phases: near-term and long-range planning. Near-term planning is less flexible because the time, and the financial and material resources may not be available. This means that near-term needs may not be fully satisfied immediately. Long-range plans do reflect all deficiencies because adequate time is available to prepare for weapons production. The equations for the allied production plans are:

```

FOR IA1=1,36
L  APLAN.K(IA1)=APLAN.J(IA1)+DT*(APACC.JK(IA1))
R  APACC.KL(IA1)=MIN(ASDEV.K(IA1),APPC.K)
A  ASDEV.K(IA1)=SUMV(ADWSL.K(*),1,36)+CLIP(1,0,T(IA1),12)/
X  (36-AURG.K)
NOTE  APLAN  ALLIED PLANNED PRODUCTION

```


NOTE APACC ALLIED PRODUCTION ACCELERATOR
 NOTE ASDEV ALLIED SCHEDULE DEVIATION
 NOTE APPC ALLIED PROJECTED PRODUCTION CAPACITY
 NOTE ADWSL ALLIED DESIRED WEAPON SYSTEMS LEVEL
 NOTE AURG ALLIED URGENCY--TIME TO FIRST DEFICIENCY
 NOTE T TIME
 FOR IA2=37,120
 L APLAN.K(IA2)=APLAN.J(IA2)+DT*(ALRADJ.K(IA2-36))
 R ALRADJ.KL(IA2-36)=CLIP(NAWS.K(IA2),0,ADECP.K,ADECB.K)
 NOTE ALRADJ ALLIED LONG-RANGE ADJUSTMENT RATE
 NOTE NAWS NUMBER OF ALLIED WEAPON SYSTEMS
 NOTE ADECP ALLIED DECISION TO PRODUCE
 NOTE ADECB ALLIED DECISION TO BUY

The allied intent to use force is a function of the threat perceived. As threat increases, the allies may seek other alliances if the U.S. is not able or willing to provide support. This action changes the allied intent towards the U.S. causing a change in the deficiency equation: the allies become friendly towards the enemy, thus reducing their perceived threat. The equations which represent this concept are:

A AINT.K=TABHL(AWGT,AINTF.K,-1,1,.2)
 A AINTF.K=SMOOTH(SUM(APTHR.K)/120,3)
 T AWGT=0/0/0/.05/.10/.25/.45/.85/.99/-.60/-1.00
 NOTE AINT ALLIED INTENT TO USE FORCE
 NOTE AINTF ALLIED INTENT FACTOR
 NOTE APTHR ALLIED PERCEIVED THREAT
 A ADPCT.K=TABLE(APFT,AINT.K,-1,1,.2)
 T APFT=-1.0/-.86/-.25/-.15/-.05/0/.05/.15/.25/.60/.65
 NOTE ADPCT ALLIED PERCENTAGE OF DEFICIENCY

The allied decision concerning production or purchase of weapons is influenced by the ability of their industrial base to produce weapons. The flow diagram

contained in Figure 5-31 depicts the decision structure which exists to determine make or buy decisions. The following equations correspond to the diagram.

```

A  ARUCWS.K=RAADP.K*RESCF.K
A  RESCF.K=TABXT(RSCFT,RAADP.K,0,100,10)
T  RSCFT=1.E6/1.E4/1000/650/400/200/140/80/40/10
NOTE  ARUCWS  ALLIED RESOURCE UNIT CONSTRAINT PER WEAPON SYSTEM
NOTE  RAADP    RESOURCES ALLOWED FOR ALLIED DEFENSE PRODUCTION
NOTE  RESCF    RESOURCE COST FACTOR
A  ACAPDP.K=MIN(ARUCWS.K,AGNP.K*APGNPD)
NOTE  ACAPDP  ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE  ARUCWS  ALLIED RESOURCE UNIT CONSTRAINT PER WEAPON SYSTEM
NOTE  AGNP    ALLIED GROSS NATIONAL PRODUCT
NOTE  APCNPD  ALLIED PERCENT OF GNP TO DEFENSE
C  APCNPD=.003
N  AGNP=1E10
L  AGNP.K=AGNP.J+DT*(AGNPGR.JK)
R  AGNPGR.KL=AGNP.K*AGNPGF
C  AGNPGF=.002
NOTE  APCNPD  ALLIED PERCENT OF GNP TO DEFENSE
NOTE  AGNP    ALLIED GROSS NATIONAL PRODUCT (GNP)
NOTE  AGNPGR  ALLIED GNP GROWTH RATE
NOTE  AGNPGF  ALLIED GNP GROWTH FACTOR
NOTE  ACAPDP  ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE  ADECP   ALLIED DECISION TO PRODUCE

```

Productive capacity is determined by the constraints from resources and the economy. If more capacity exists than is planned for defense, the allied desire to co-produce increases. If the productive capacity is not sufficient to meet all needs for defense production, the allied nation must consider foreign military sales with the U.S.

The allied decision process relative to foreign military sales is depicted in the flow diagram contained in Figure 5-32. The equations for this diagram follow:

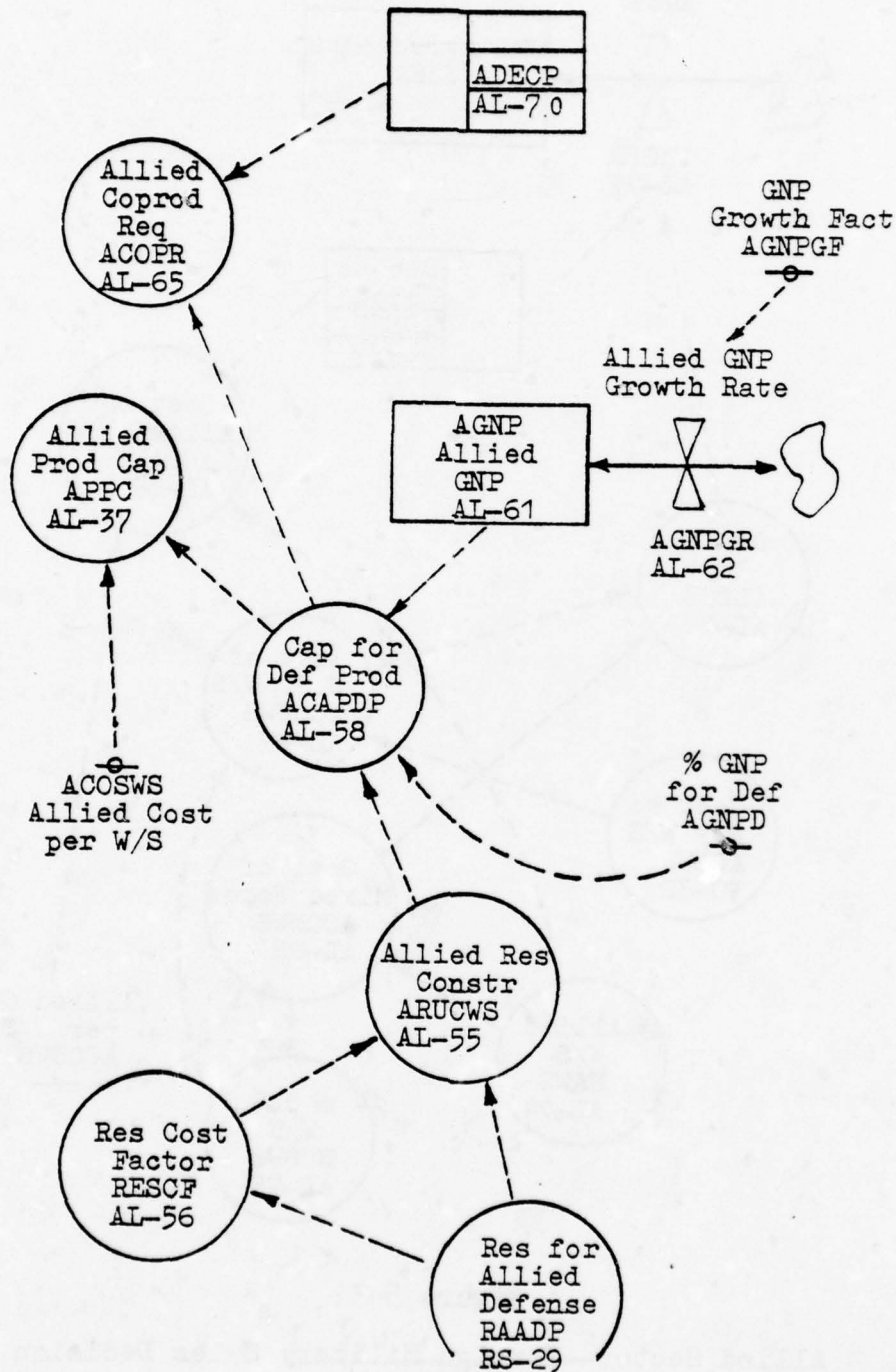


Figure 5-31

Allied Sector--Production Capacity

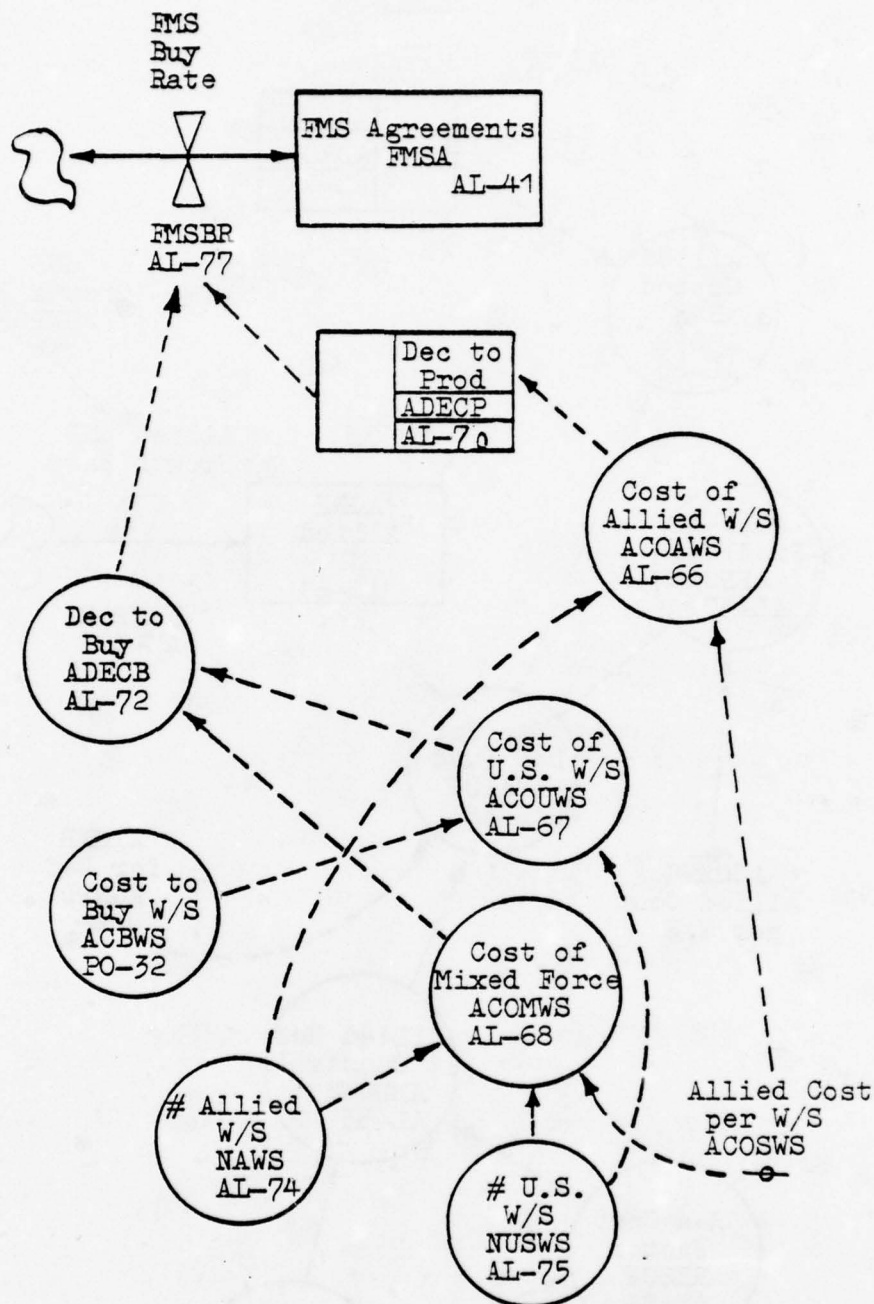


Figure 5-32

Allied Sector--Foreign Military Sales Decision


```

A  NAWS.K(MO)=CLIP(APTHR.K(MO)-USCPWS.K*COMP.K(MO),ADWSL.K(MO),
X  ADECP.K,ACOAWS.K)
NOTE  NAWS  NUMBER OF ALLIED WEAPON SYSTEMS PLANNED
NOTE  COMP  COMPUTED TRADEOFF FACTOR
NOTE  ADECP  ALLIED DECISION TO PRODUCE
NOTE  ACOAWS  ALLIED COST FOR ALLIED WEAPON SYSTEMS
A  NUSWS.K(MO)=CLIP(ACPWS*COMP.K(MO),APTHR.K(MO)/USCPWS.K,
X  ADECP.K,ACOWS.K)
NOTE  NUSWS  NUMBER OF US WEAPON SYSTEMS PLANNED
NOTE  ACPWS  ALLIED CAPABILITY PER WEAPON SYSTEM
NOTE  COMP  COMPUTED TRADEOFF FACTOR
NOTE  ADECP  ALLIED DECISION TO PRODUCE
NOTE  ACOWS  ALLIED COST FOR US WEAPON SYSTEMS
A  COMP.K(MO)=(ACOWS*APTHR.K(MO)-ACAPDP.K)/(USCPWS.K*ACOWS
X  -ACPWS*ACOWS.K)
NOTE  ACAPDP  ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE  ACOWS  ALLIED COST TO BUY WEAPON SYSTEMS

```

The decision process involves a trade-off of cost and threat considerations of three alternatives: total self-sufficiency, a mix of U.S. and allied inventory, or foreign military sales. The goal in this trade-off is assumed to be cost oriented as long as the deficiency is satisfied. The evaluation which precedes this decision involves an analysis of cost, desire for weapon systems, threat, current plans, and capability. The decision which results from this analysis and the inventory mix determination establishes the basis for foreign military sales desires. The equations which represent the inventory mix are:

```

L  FMSA.K(MO)=FMSA.J(MO)+DT*(FMSBR.JK(MO))
R  FMSBR.KL(MO)=CLIP(NUSWS.K(MO),0,ADECP.K,ADECB.K)
NOTE  FMSA  FOREIGN MILITARY SALES AGREEMENT
NOTE  FMSBR  FOREIGN MILITARY SALES BUY RATE
NOTE  NUSWS  NUMBER OF US WEAPON SYSTEMS PLANNED
NOTE  ADECP  ALLIED DECISION TO PRODUCE
NOTE  ADECB  ALLIED DECISION TO BUY

```



```

A  ACOAWS.K=SUM(ADWSL.K)*ACOSWS
A  ACOUWS.K=SUM(APTHR.K)*ACBWS.K/USCPWS.K
A  ACOMWS.K=SUM(NAWS.K)*ACOSWS+SUM(NUSWS.K)*ACBWS.K
NOTE  ACOAWS  ALLIED COST FOR ALLIED WEAPON SYSTEMS
NOTE  ACOSWS  ALLIED COST PER WEAPON SYSTEM
NOTE  ACOUWS  ALLIED COST FOR US WEAPON SYSTEMS
NOTE  ACBWS   ALLIED COST TO BUY WEAPON SYSTEMS
NOTE  USCPWS  US CAPABILITY PER WEAPON SYSTEM
NOTE  NAWS    NUMBER OF ALLIED WEAPON SYSTEMS PLANNED
NOTE  NUSWS   NUMBER OF US WEAPON SYSTEMS PLANNED
A  ADECB.K=MIN(ACOUWS.K,ACOMWS.K)
A  ADECP.K=SMOOTH(MIN(ADECB.K,ACOAWS.K),1)
NOTE  ADECB   ALLIED DECISION TO BUY
NOTE  ACOUWS  ALLIED COST FOR US WEAPON SYSTEMS
NOTE  ACOMWS  ALLIED COST FOR MIXED WEAPON SYSTEMS INVENTOR
NOTE  ADECP   ALLIED DECISION TO PRODUCE

```

The role of allied defense in the worldwide military environment is important. As allies seek to protect themselves from enemy threat, the total U.S./allied capability increases and presents a threat to the enemy.

Enemy Sector

The final sector depicts the flow of weapon systems and the related information network applicable to enemy defense. This sector depicts two primary structures. The first is the actual flow of inventory in the enemy defense system. The second depicts the threat analysis, political intentions, and defense planning activities. The enemy sector flow diagrams are provided in Figure 5-33 and 5-34. The similarities to the allied structures contained in Figure 5-28 and 5-30 should be noted. The equations which

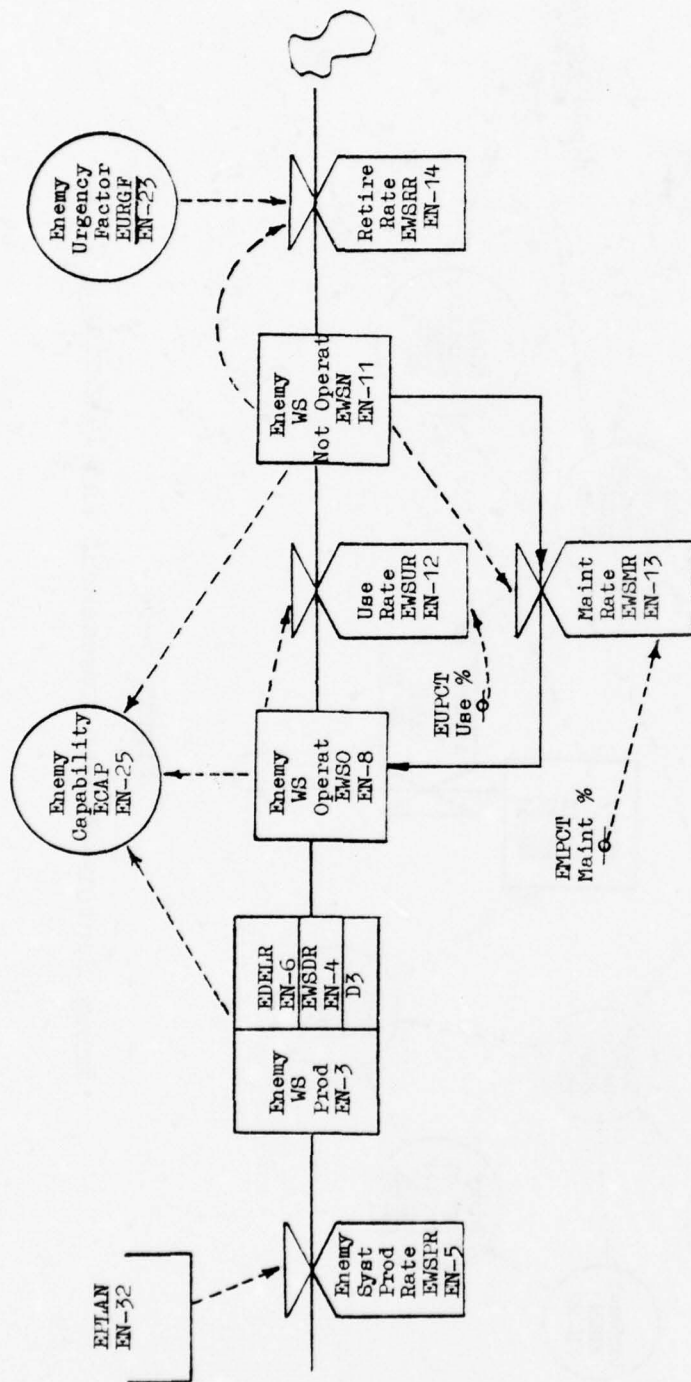


Figure 5-33
Enemy Sector--Inventory

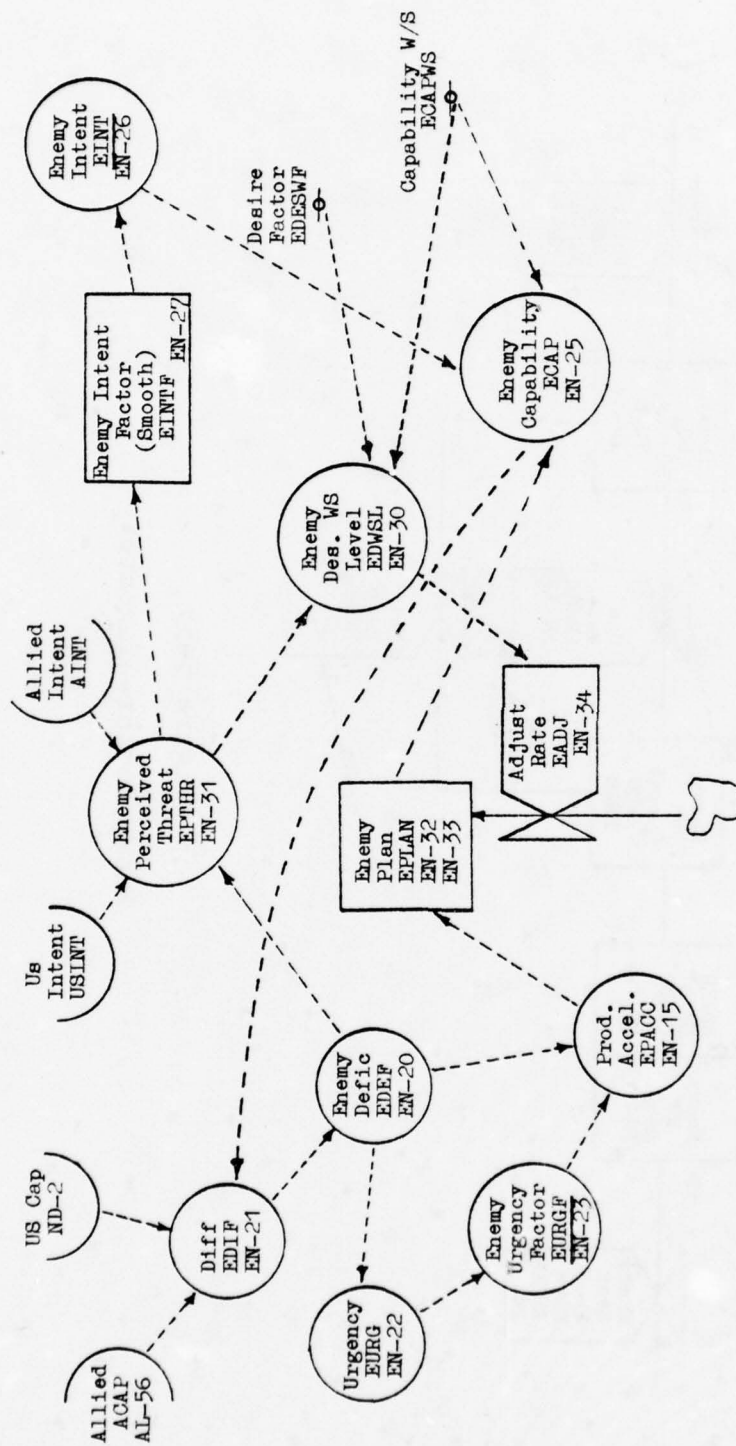


Figure 5-34
Enemy Sector--Threat Assessment and Planning

represent the flows of inventory in the enemy system are given below:

```

L  EWSP.K=EWSP.J+(DT)(EWSPR.JK-EWSDR.JK)
R  EWSDR.KL=DELAY3(EWSPR.JK,EDEL.R.K)
R  EWSPR.KL=FSHIFT(EPLAN.K)
NOTE  EPLAN  ENEMY PLANNED PRODUCTION
NOTE  EWSP   ENEMY WEAPON SYSTEMS PRODUCTION
NOTE  EWSPR  ENEMY WEAPON SYSTEMS PRODUCTION INPUT RATE
NOTE  EWSDR  ENEMY WEAPON SYSTEMS DELIVERY RATE
A  EDEL.R.K=24/EURGF.K
NOTE  EDEL.R  ENEMY PRODUCTION DELAY FACTOR
NOTE  EURGF  ENEMY URGENCY FACTOR
L  EWSO.K=EWSO.J+(DT)(EWSDR.JK+EWSMR.JK-EWSUR.JK)
NOTE  EWSO   ENEMY WEAPON SYSTEMS OPERATIONAL
L  EWSN.K=EWSN.J+(DT)(EWSUR.JK-EWSMR.JK-EWSRR.JK)
NOTE  EWSN   ENEMY WEAPON SYSTEMS NON-OPERATIONAL
NOTE  EWSRR  ENEMY WEAPON SYSTEMS RETIREMENT RATE
R  EWSUR.KL=EUPCT*EWSO.K
NOTE  EUPCT  ENEMY PERCENTAGE OF WEAPON SYSTEMS USED
R  EWSMR.KL=EMPCT*EWSN.K
NOTE  EMPCT  ENEMY PERCENTAGE OF WEAPONS REPAIRED
R  EWSRR.KL=EWSN.K+.002/EURGF.K
A  ECAP.K(MO)=(EWSP.K+EWSO.K+EWSN.K+SUMV(EPLAN.K(*),
X  1,T(MO))) *ECAPWS
NOTE  ECAP   ENEMY CAPABILITY
NOTE  EPLAN  ENEMY PLAN FOR WEAPON SYSTEMS PRODUCTION
NOTE  ECAPWS  ENEMY CAPABILITY PER WEAPON SYSTEM

```

The only real differences in the allied and enemy sectors are the exclusion of arms transfers in the enemy sector and the values of goals established by the enemy. In many cases, the enemy was assumed to establish higher goals concerning weapon system inventory and desired capability. These desires influence the worldwide threat situation.

The equations which apply to the enemy evaluation of threat are similar to the concepts presented in both

the U.S. and allied defense systems. Threat is a function of the relative difference in capability and the intent of others to use force. This threat, in turn, determines the intent of the enemy towards others. The equations which apply to enemy threat are:

```

A  EINT.K=TABHL(EINTT,SUM(EPTHR)/120,-1,1,.2)
NOTE  EINT  ENEMY INTENT
NOTE  EPTHR  ENEMY PERCEIVED THREAT
T  EINTT=1.99/1.7/1.3/1.15/1.05/1/1.05/1.15/1.3/1.7/1.99
A  EINTF.K=SMOOTH(SUM(EPTHR)/120,3)
NOTE  EINTF  ENEMY INTENT FACTOR
A  EDWSL.K(MO)=EDESWF*EPTHR.K(MO)/ECAPWS
NOTE  EDWSL  ENEMY DESIRED WEAPON SYSTEMS LEVEL
NOTE  EDESWF  ENEMY DESIRE FOR WEAPONS FACTOR
NOTE  ECAPWS  ENEMY CAPABILITY PER WEAPON SYSTEM
A  EPTHR.K(MO)=(USINT.K+AIN.T.K)*EDEF.K(MO)
NOTE  USINT  US INTENT
NOTE  AINT  ALLIED INTENT
NOTE  EDEF  ENEMY DEFICIENCY

```

The deficiency is determined by the evaluation of U.S., allied, and enemy capabilities. The difference between the capability is considered the deficiency which will be included in the enemy production plan. The equations are:

```

A  EDEF.K(MO)=MAX(EDIF.K(MO),0.0)
NOTE  EDEF  ENEMY DEFICIENCY
NOTE  EDIF  ENEMY DIFFERENCE IN CAPABILITY
A  EDIF.K(MO)=USCAP.K(MO)+ACAP.K(MO)-ECAP.K(MO)
NOTE  USCAP  US CAPABILITY
NOTE  ACAP  ALLIED CAPABILITY
NOTE  ECAP  ENEMY CAPABILITY
A  EURG.K=URGENCY(EDEF.K)
NOTE  EURG  ENEMY URGENCY--TIME TO FIRST DEFICIENCY
T  EWGT=2.0/1.75/1.35/1.15/1.05/1/1.99/.98/.97/.96
A  EURGF.K=TABLE(EWGT,EURG.K,0,120,12)
NOTE  EURGF  ENEMY URGENCY FACTOR

```


The final concept within the enemy sector is the development of the production plan. The plan is similar to the concept described for the allied sector; however, no resource constraints are considered. Near-term plans are considered less flexible than long-range plans because of the planning cycle required to develop and evaluate industrial capability and provide financial and material resources to defense production. The equations that represent enemy production planning are:

```

FOR ME=1:36
L  EPLAN.K(ME)=EPLAN.J(ME)+(DT)(EPACC.JK)
NOTE  EPLAN  ENEMY PLAN FOR WEAPON SYSTEMS PRODUCTION
NOTE  EPACC  ENEMY PRODUCTION ACCELERATOR
FOR MEE=37:120
L  EPLAN.K(MEE)=EPLAN.J(MEE)+DT*(EADJ.JK(MEE-36))
R  EADJ.KL(MEE-36)=EDWSL.K(MEE)
NOTE  EADJ   ENEMY ADJUSTMENT RATE

```

In summary, the enemy sector is developed in less detail because less information is available to managers in the U.S. acquisition system about the decision process. The conclusions made about enemy decisions result from evaluation of hardware inventories, plans, and the political environment which affects the goals and desires of the enemy defense system. Enemy goals provide the basis for

the positive feedback loop which is characterized by the arms race. This becomes the stimulus for DOD mission requirements and subsequent acquisitions of weapon systems and military equipment.

Summary

In this chapter the decision structure which affects actions in the DOD acquisition process was developed. The system dynamics methodology provided a meaningful way to display the important states, flows, and decisions which exist. These concepts were further enriched by mathematical equations which provide greater detail to the concepts which have been developed throughout this thesis. The analysis of the descriptive information contained in Chapter 4 and the structural information contained in this chapter provide great insight into the reasons for much of the behavior in the systems acquisition process. This insight increases management's understanding of the system processes and provides a basis to determine the impact of policy decisions prior to implementation.

In the next chapter, the conclusions of the research will provide a basis for recommendations to improve the system and address the managerial applications of policy modeling of complex and dynamic systems.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The primary goal of this research was to develop a policy model of the DOD systems acquisition process. The model was developed to assist management in understanding the complex and dynamic nature of the system and to provide a tool for policy development and analysis. As noted in Chapter 1, eight specific objectives were established in order to achieve this goal. The objectives were:

1. identify the structure of the systems acquisition process;
2. isolate the interactions and influence of the components and variables within the system;
3. describe the decision structure that determines the information, money, and material flows within the system;
4. construct a mathematical model which represents the components, relationships, information flows, and decisional policies of the system;
5. develop a computerized model which can be used for policy analysis and development;
6. verify and validate that the model represents the structure and decision-making process within the systems acquisition process;
7. identify areas of sensitivity or critical issues in acquisition policy; and

8. suggest changes, if required, in the management structure of the systems acquisition process.

The purpose of this chapter is to summarize the research effort by review of the research methodology and findings relative to each objective. In addition, conclusions and recommendations for management application of the policy model will be addressed. Finally, suggestions for further research will be proposed in order to extend the theory and application of policy modeling of the systems acquisitions process within DOD.

Summary of Research

The first objective of this research was to identify the structure of the systems acquisition process. This involved identification of the major components within the system as well as defining the system boundary. The structure was extended beyond the traditional processes that are associated with acquisition. The purpose of extending the boundaries was to capture the political process which affects the goals and policies established for DOD and the acquisition of major weapon systems. The political process involves internal U.S. and international relationships. The system was divided into ten sectors in order to assist in analysis and model construction. These sectors are explained in greater detail in the conceptual model presented in Chapter 4. The sectors included were:

Political, Need, Financial, Technology, Weapon Systems Research and Development, Resources, Production, U.S. Operations, Allied Defense, and Enemy Defense. The elements within each sector and relationships between sectors provided a means to achieve the second objective.

The isolation of interactions and influences between variables within the system was accomplished through a two-part approach. The first resolution of the model was developed as a result of knowledge obtained from a formal literature review, experience, and observations about the system. The second part of the research involved verifying and validating the relationships by discussions with key managers within the acquisition system. The results of this effort are presented in the description and diagrams contained in Chapter 4. The research revealed that several key variables within the system influence many of the decisions and processes. These variables determine the nature of the major feedback loops. Threat and capability appeared to be the driving factors in the identification of needs. Approval of needs was influenced by the political environment which included international intentions and specific desires for DOD weapon systems. The satisfaction of needs was determined by both the financial process and the research, development, production, and deployment of weapons. The dollars provided to DOD for system acquisitions

represent the implicit policy concerning the relative importance of DOD in the achievement of national goals and objectives. The weapon system program characteristics determine the ultimate capability and cost of the system.

The third objective of the research was to describe the decisional structure that determined the informational, money and material flows within the system. The flow diagrams and discussion in Chapter 5 document the results of this effort. Four specific decisional structures were studied in relationship to the system. The first was the mission-area planning structure that exists to identify and evaluate needs. This structure was difficult to capture because of the vagueness of threat and capability assessments. Recently, a new technique has been applied which aims to institutionalize a procedure which may lead to improvements in the process. The second process which was analyzed was the Defense Systems Acquisition Review Council decisions. This group is responsible for making the decisions which relate to approving mission area needs. In this decision, the trade-offs between various alternatives to satisfy a specific need were addressed. The new policies implementing OMB Circular A-109 have somewhat altered the decisional process; therefore, the relative weights of the decisional variables appear to be changing. The third decisional process which was developed in the model is the

programming and budgeting process which determines the amount of dollars available for DOD acquisitions. This process seeks to evaluate the various funding alternatives to be pursued within DOD. All three of these decisional structures require a large amount of data in order to evaluate alternatives. The research revealed that although much data were provided to the decision-makers, few alternatives were actually evaluated. The major reasons given for this were the volume and the timing of information. The fourth decisional structure in the model was the program management evaluations required to achieve cost, schedule, and performance goals. The research indicated that there was a general bias to forego cost aspects of a program in order to meet schedule and performance goals; however, cost was becoming more important to the decisional process. In summary, the decisional processes relative to systems acquisitions are similar. Research revealed that managers use similar information to make decisions; however, the amount, timing, and format of information partially determined the number of trade-offs that are made between and among alternatives.

The fourth research objective was to develop a mathematical model which represented the components, relationships, information flows, and decisional policies of the system. This was accomplished by developing the

structural model contained in the flow diagrams into mathematical relationships believed to represent the system. The specific measurement and dimensions of the variables resulted from the functional relationships noted in the literature review and the interview process. Parametric techniques were not used; however, the relationships provide meaningful representations of the real system. The measurement criteria for several concepts was very difficult to develop. These concepts include variables such as threat, capability, technology, and political desires. Consideration of these variables was accomplished by developing comparative measures to portray the relationships which existed between variables that were not well measured in the actual acquisition system. The system equations are presented in Chapter 5.

The mathematical equations were developed using the DYNAMO simulation notation in order to accomplish the fifth research objective. Experiments with the simulation model are recommended for policy analysis and development; however, this was beyond the scope of this research. At the close of the research effort, the model was tested and initial results indicated there were no major defects with the system logic, although additional testing was required to fully verify and validate the model operation. It may now be used for policy analysis.

Although the model was not exercised fully, the sixth research objective was accomplished by verifying and validating the model concept and structure. This task was accomplished throughout the research to ensure internal validity and to verify that the model was consistent with development intentions. This repetitive approach led to model integrity even though the behavior of the system was not observed through model operation. The confirmation of concepts and system structure addressed in the interview process provided credence to the model validity and usefulness in policy analysis.

The seventh research objective was to identify areas sensitive to the system behavior. The issues and discussions in Chapter 4 identify areas of current concern. Specific attention was given to the political goals and desires of the system. The power and inclinations of the political process make it important to understand the role of the systems acquisition in national policy development. The impact of this process normally is expressed in dollars which are provided for DOD research, development, production, and operations. The system was noted to be very stable. Analysis of past performance and results of policy changes indicated that the long delays within the system create much of the stability, despite the cyclical actions of the DSARC and funding processes. The complexity of the

system appears to make it difficult to institute changes in system behavior when only several variables are changed. Forrester stated that this is characteristic of multi-looped systems of complex systems. The important areas which appear to affect the system are in the major feedback loops. The evaluation of threat and capability is essential to determining the requirements which must be satisfied by systems acquisition and support. The political environment is also essential to the behavior of the system. Finally, the goals that are established within DOD for specific weapon system performance characteristics impacts the downstream cost, schedule, and operational performance of the system.

The eighth research objective will be addressed in the following sections of this chapter. The suggestions and recommendations to management illustrate the power which results from careful analysis of system relationships and decisional structures within large, complex systems.

Conclusions

The presentation of this research has indicated that the systems acquisition process is indeed complex. The development of a policy model provided a valuable tool for both policy analysis and development. The models presented in Chapters 4 and 5 are the basis for the

following conclusions, recommendation for improvements, and the implication of policy-model use in analysis and development of DOD acquisition policy. These conclusions represent the preliminary analysis of the policy structure within the system; however, it is recommended that the full impact of the policy decisions which result from analysis be evaluated through exercising the simulation model developed in this research.

The first general research conclusion concerns the system decision structure. The structure which supports policy decisions in the DOD systems acquisition process does not appear to be well integrated. This was noted throughout the system processes which support decisions concerning planning, programming, budgeting, and approving needs. Key decisions relative to acquisition are difficult to make due to the multiple goals in the system, vagueness and inconsistencies within performance measures, and the nature of the information flow. Because decisions are difficult, the integrative process is essential to balance the requirements for military support. The problem appears to result from a lack of both horizontal and vertical integration of requirements and information. Horizontal integration is required in order to make the necessary trade-offs between mission areas and funding appropriations. Vertical integration is required to provide consolidated information to strategic

level managers, rather than details which exist at the operating levels of the acquisition hierarchy. It is believed that the executive and legislative branches of government should serve in this integrative capacity; leaving the details of specific acquisition management problems to the Services. The strategic levels in the acquisition hierarchy must make the broad trade-offs and establish long-term goals. Implementation of the decisions and goals should be the responsibility of the lower levels of the organization as long as the intent and purpose of the policy is consistently implemented.

The second general research conclusion concerns the goal structure within the DOD systems acquisition process. There is a variety of goals established for the various sub-parts of the system. Many times these goals are in conflict or are not consistent within the levels of the organization hierarchy. These goals relate to the missions and performance measures established within each process and level within the system. As noted in Chapter 4, there are many goal seeking loops within the system. Goal disparity was apparent, particularly in the needs process. This disparity results from the performance, cost, and schedule aspects of DOD weapon systems. In addition, the goals of the political process often conflict with the established goals within DOD.

The research also revealed that there was little integration of the various sub-goals in the system. Many of the differing sub-goals resulted from the relative position of the decision-maker or organization within the acquisition hierarchy. The focus on hardware and performance goals at the operational level has not been integrated with the funding and political goals which affect the strategic level management decisional structure. The goal disparity has led to much confusion, specifically noticed in the implementation of OMB Circular A-109 policy regarding mission needs.

In addition to goal disparity resulting from mission or position in the acquisition process, the impact of short-term goals on the decision process was observed. The goals established in acquisition favor achieving near-term goals without full realization of the long-term behavioral effect. This point is illustrated by the general disregard for downstream life cycle costs associated with weapons system operations and support. Although recent trends look more promising than past actions, current research and development goals often preempt the consideration of long-term effects on logistics support.

The third general research conclusion concerns the performance measures used in system acquisition. As noted in the preceding paragraph, the measures may not be

consistent within the various levels and processes within acquisition. In addition to this, research revealed that many performance measures were not well developed, leading to vagueness and confusion within the system. Several areas are specifically noted because they are considered the primary factors within the system. They include: threat, capability, research and development progress, technology, and political desires and intentions. The acquisition process can be improved if a clear understanding and meaningful measurement devices can be developed to assist in evaluating system performance. It is believed that measures can be developed for variables. Management attention should focus on developing and implementing consistent performance measures for the variables mentioned above. Of particular concern are measures for threat and capability. These measures are considered to be the primary determinants of acquisition needs. Better measures in these areas should assist in evaluating system requirements and provide a means to develop consistent plans. In addition to this, the behavior of the system may become more apparent if the vagueness of the system's performance measures is removed.

The fourth general research conclusion is intended to draw the first three conclusions together and provide the basis for a recommendation to improve the system. The flow of information throughout the system determines the

decisional environment. The research revealed that the information flow within the systems acquisition process does not always support the decisions which must be made. This leads to inappropriate policies. As noted in Chapter 1, managers that operate with mental models of the processes within their responsibility often make inconsistent and incorrect decisions due to the complex and dynamic nature of the decision-making environment. The establishment of an appropriate information system to assist managers within all levels in the acquisition process is required. The system should focus on providing timely, appropriate information which is aggregated to the extent necessary for each level of management and decision-making situation. The result of this management information system should assist in making better decisions and appropriate trade-offs. In addition, the information system should address the needs to develop specific performance measures. The policy model should be used to identify the specific areas of sensitivity which can be improved through better measurement and understanding of the system process.

In addition to exercising the model to determine the areas of sensitivity, managers within the acquisition should operate the model in conjunction with policy analysis and development. Two specific uses are foreseen. The model provides an excellent tool to evaluate the effects of

structural changes to the system. For example, the DSARC and PPBS systems could be linked together to determine whether the system behavior improves as a result of this policy decision. The second use for policy analysis is to evaluate the response of the system to changes in various system states. This could be used to determine the effect elements such as increasing worldwide threat or economic conditions within the country. These examples are but a few of the potential issues and problems which can be studied using the policy model. In addition to this, the model provides a powerful tool for evaluating the impact of proposed policy decisions before they are implemented in the real system.

Recommendations for Further Study

Further study is recommended in order to realize the full benefits of the policy model developed in this research. The scope of this research did not include the actual operation and analysis of the policy model in a dynamic environment. The operation of the model is recommended in order to analyze the behavior of the system over time. In addition, policy experiments should be developed to assist managers in developing effective policy for the acquisition system.

Validation of the system behavior through comparison of simulated behavior with actual historical trends is also

recommended. This process should seek to refine variables and concepts as necessary to ensure an accurate representation of the real system. This research began the validation process; however, comparison with a real system environment was beyond the research scope.

The results of model operations are two-fold, each leading to further study. First, the model operation may identify areas which are highly sensitive to policy decisions or environmental situations. These areas should be the focus of specific efforts to develop precise relationships between variables using empirical analysis. Second, the search for information to develop these relationships should also consider the needs for performance measures and the information system discussed in the previous section.

Several specific areas in the model require further study in order to fully represent the system. The first area is to develop the flow of manpower within the system. Several simplifying assumptions were required in the current model. The visibility over skills, motivation, and experience could provide additional insight and meaning to the model. A second area concerns the precise relationship of the political and economic conditions on the systems acquisition process. The general linkages are portrayed; however, specific relationships were not explicitly developed. Of specific concern is the motivations of the defense

industry and the increasing importance of the military alliances which affect the systems acquisition process. The final area for model expansion is the inclusion of capital equipment and production facility constraints. The research revealed conflicting information about this essential part of the system, more in-depth analysis is required.

In summary, the use of a policy models can increase the understanding of the dynamic and complex processes which relate to the systems acquisition process. The impact of policy decisions can be analyzed through policy experiments in a simulation environment. This feature is, perhaps, the most valuable to management because expectations and response of the system to changes guide strategic management's policy decisions and determine the ultimate behavior of the system. It is the authors sincere hopes that this research will be continued and contribute to the policy-making capabilities of management within the DOD systems acquisition process.

APPENDIX A
INTERVIEW GUIDE

1. Goals and Objectives

What are the major objectives or products relative to your organization's role in the acquisition process?

2. Decision Situation

a. In your area, what is one of the most critical decisions you have made concerning the acquisition process in the last month?

b. Is this decision representative of the types of decision situations in which you are involved?

c. If not, could you give me an example of recurring type of decision which you are required to address?

3. Information Channels--Input

a. How did you become aware of the problem or issue that required a decision?

Who?

Organization--chain of command?

External to organization?

Formal document?

Informal communication?

b. Did you seek assistance or ask for further information before making the decision?

Who did you go to?

What kind of help did you request?

How did you request assistance (formal, informal)?

4. Decision Making Process and Refinement of Attributes

a. Did you consider any alternatives before making the final decision?

What were the alternatives?

b. What do you consider the major pros and cons to the alternatives?

c. Why do you consider the decision you made to be superior to the other alternatives?

5. Performance Measurement

a. How will the implementation of your decision be monitored?

Who will be responsible?

What is their relationship to you?

b. How will the results be measured? Is there a predetermined set of standards or performance measured established?

c. Could you give me an example of an acquisition program that you consider to be well managed? What specific characteristics of the program highlight the strengths of the program?

6. Output and Feedback

a. What do you expect the impact of this decision to be in your area and also on others in your organization, other organizations, and the environment?

b. Who would benefit or lose by this decision?

7. Delays

In your estimation, how long will it take before the results of this decision will have an effect? Do you consider this to be complete implementation, or will there be a gradual response to your decision?

8. Timing and Dynamics of Situation

a. At the time you made the decision, would you have followed a different problem solving procedure if there had been more/less time available? Explain.

b. Knowing what you know now, would you have made a different decision than you did before?

9. General Information About Key Issues

a. In your opinion, what are some of the continuing problems or issues in the system acquisition process that the DOD has not succeeded (or has ignored) in correcting?

b. Do you feel these problems can be corrected or the issues resolved? If so, how would you propose to do it?

c. What are some of the major trends or changes you see in the future?

APPENDIX B
PERSONAL INTERVIEWS

--Colonel Kyle D. Barnes, USAF, Director of Mission and Functional Planning, Air Force Systems Command.

--Lt. Col. Juan Benjamin, USAF, Aeronautical Systems Division, Air Force Systems Command.

--Lt. Col. Lynn T. Berringer, USAF, Integration Branch Action Officer, Foreign Technology Division.

--Colonel R. E. Brence, USAF, Deputy Director of Contracting and Acquisition, HQ USAF (RDC).

--Major General James L. Brown, Assistant Chief of Staff for Intelligence, HQ USAF.

--Lt. Col. Walter T. Bryan, USAF, Chief, Operational Requirements Management Group, HQ USAF, Deputy Chief of Staff for Research and Development.

--Budget Examiner Allan V. Burman, National Security Division, Office of Management and Budget.

--Mrs. Deborah P. Christie, Director, Mobility Forces Division, DCS, Program Analysis and Evaluation, Office of the Secretary of Defense.

--David Chu, Assistant Director for National Security and International Affairs, Congressional Budget Office.

--Major General Gerald E. Cooke, Commandant, Air Force Institute of Technology.

--John Cove, Budget Committee, U.S. House of Representatives.

--Ronald Davidson, Program and Budget Division, Office of the Secretary of Defense (Comptroller).

--H. L. Everett, Associate Director of Maintenance and Supply, HQ USAF (LEY).

--Major Bruce Ewing, USAF, Engineering and Support Division, HQ USAF (LEYE).

--Donald Gessaman, Chief, Navy Branch, National Security Division, Office of Management and Budget.

--Harvey J. Gordon, Deputy for Acquisition, Office of the Secretary of the Air Force.

--Lt. Col. Robert H. Hale, Directorate of Development and Programming Branch, HQ USAF.

--Gary D. Hooper, Budget Examiner, National Security Division, Office of Management and Budget.

--Glen R. Hoover, F-15 Systems Program Office, Aeronautical Systems Division, Air Force Systems Command.

--Terry L. Jenkins, Mission Area Analysis, Air Force Acquisitions Logistics Division, Air Force Logistics Command.

--Lt. Col. Frank N. Koval, USAF, Acting Chief, Operational Test and Evaluation Division, HQ USAF, Directorate of Operational Readiness.

--Major Robert E. Linhard, USAF, Planning and Programming Officer, HQ USAF, Force Capabilities Integration Division.

--Dr. Andrew J. Marshall, Director of Net Assessment, Offices of the Secretary of Defense.

--Lloyd Moseman, Deputy Assistant Secretary of the Air Force (Logistics), SAF.

--Colonel B. J. Ratledge, USAF, Deputy Director, Investment Appropriations Division, HQ USAF (ACBI).

--Herman A. Shipley, Office of Federal Procurement Policy.

--Russell Shorey, Directorate of Manpower, Reserve Affairs and Logistics, Office of the Secretary of Defense

--Colonel Robert Sigethy, USAF, Deputy Director, Office of Scientific Research.

--John E. Smith, Deputy Director, Major Systems Acquisition, DCS Research and Evaluation, Office of the Secretary of Defense.

--Colonel R. C. Smith, USAF, Management Policy Division, Chief, Directorate of Development and Programming Policy, HQ USAF (RDP).

--Perry Stewart, Director of Concepts and Analysis, Air Force Acquisition Logistics Division (XRS).

--Richard A. Stubbing, Deputy Chief of the National Security Division, Office of Management and Budget.

--Edward Trusella, Principle Assistant, DCS Contracting and Manufacturing, Air Force Systems Command.

--Peter Van Scheik, Air Force Propulsion Laboratory.

--Colonel Karl R. Wiegard and Mr. Ed Bando, Director of Policy and Programs, Air Force Systems Command.

--Colonel Bernard Weiss, USAF, Director of Procurement and Manufacturing, Aeronautical Systems Division.

APPENDIX C
COMPUTER LISTING AND FLOW DIAGRAMS

NOTE ***** POLITICAL SECTOR *****

NOTE

A QOL.K=TABHL(QLMT,GNP,K/SPTHR,K,0.5,1) PO- 1

T QLMT=.2/1/1.7/2.3/2.7/2.9 PO- 2

NOTE

NOTE QOL QUALITY OF LIFE

NOTE GNP GROSS NATIONAL PRODUCT

NOTE SPTHR SMOOTHED PERCEIVED THREAT

NOTE

L GNP.K=GNP.J+DT*(GNPGR,JK) PO- 3

R GNPGR.KL=.03 PO- 4

A FREV.K=GNP.K*PCNPG PO- 5

C PCNPG=.23 PO- 6

A DEF.K=FREV.K-FBRQMT.K PO- 7

A BUD.K=FBRQMT.K+BRF PO- 8

NOTE

NOTE GNP GROSS NATIONAL PRODUCT

NOTE GNPGR GNP GROWTH RATE

NOTE FREV FEDERAL REVENUES

NOTE PCNPG PERCENT GNP TO THE GOVERNMENT

NOTE DEF FEDERAL DEFICIT

NOTE FBRQMT FEDERAL BUDGET REQUIREMENTS

NOTE BUD FEDERAL BUDGET

NOTE

A NDODD.K=BUD.K+PBND.K PO- 9

A PBND.K=TABHL(BUDT,NDODD,K,0.1,1) PO- 10

A DODD.K=BUD.K+PBDD.K PO- 11

A PBDD.K=1-PBND.K PO- 12

NOTE

NOTE NDODD NON-DOD DOLLARS APPROPRIATED

NOTE PBND PERCENT BUDGET TO NON-DOD

NOTE NDDMD NON-DOD DEMAND

NOTE DODD DOD DOLLARS APPROPRIATED

NOTE PBDD PERCENT BUDGET TO DOD

NOTE BUD BUDGET

NOTE

A ADVOC.K=CLIP(1,0,DDRB,K,DODD,K) PO- 13

NOTE

NOTE ADVOC ADVOCACY FOR DOD DOLLARS

NOTE DDRB DOD DOLLARS REQUESTED IN THE BUDGET

NOTE DODD DOD DOLLARS APPROPRIATED

NOTE

T BUDT=.60/.61/.62/.63/.64/.65/.69/.72/.74/.75/.76 PO- 14

C ABF=1 PO- 15

C BRF=.95 PO- 16

A FBRQMT.K=BRF*(DDMD.K+NDDMD,K) PO- 17

A DDMD.K=SUM(FYDP1,K)+SUM(FYDP2,K)+SUM(FYDP3,K) PO- 18

A NDDMD.K=GNP.K*GNPGR,JK*TABHL(NDODT,QOL,K,0.3,3) PO- 19

T NDODT=2.5/2.1/1.5/1.2/.86/.67/.42/.21/.15/.11 PO- 20

NOTE
NOTE BRF BUDGET REDUCTION FACTOR
NOTE FBRQMT FEDERAL BUDGET REQUIREMENT
NOTE DDMD DOD DEMAND FOR DOLLARS
NOTE NDDMD NON-DOD DEMAND FOR DOLLARS
NOTE FYDP FIVE YEARD DEFENSE PLANS FOR FUNDS
NOTE GNP GROSS NATIONAL PRODUCT
NOTE QOL QUALITY OF LIFE
NOTE
A PRESSF,K=PRESSC*PRPA,K*LPF,K PD- 21
C PRESSC=.5 PD- 22
A CONGSF,K=CONGSC*CRPA,K*LPF,K PD- 23
C CONGSC=.4 PD- 24
A ELYRM,K=RAMP(.02,EYM,K)+SPPTC PD- 25
A EYM,K=TIME,K*(1-PULSE(1,1,48)) PD- 26
C SPPTC=.5 PD- 27
NOTE
NOTE PRESSF PRESIDENTIAL SUPPORT FACTOR
NOTE PRESSC PRESIDENTIAL SUPPORT CONSTANT
NOTE CONGSF CONGRESSIONAL SUPPORT FACTOR
NOTE CONGSC CONGRESSIONAL SUPPORT CONSTANT
NOTE ELYRM ELECTION YEAR MULTIPLIER
C USDESW=1 PD- 28
A USPTHR,K(MD)=(EINT,K-AINT,K)*USDEF,K(MD) PD- 29
A USCOPA,K=CLIP(1,0,AINT,K*SPTHR,K,.8) PD- 30
NOTE
NOTE USDESW US DESIRABILITY TO BUILD WEAPONS
NOTE USPTHR US PERCEIVED THREAT
NOTE EINT ENEMY INTENT
NOTE AINT ALLIED INTENT
NOTE USDEF US DEFICIENCY
NOTE USCOPA US COPRODUCTION AGREEMENT
NOTE SPTHR SMOOTHED PERCEIVED THREAT
NOTE
A EQUATION NOT USED PD- 31
A EQUATION NOT USED PD- 32
A USINT,K=TABHL(USINTT,SPTHR,K,0,2,.2) PD- 33
T USINTT=0/0/0/0/1/.8/1.25/1.97/2.35/2.5/2.6 PD- 34
A SPTHR,K=USURCF,K+SUM(USPTHR,K)/120 PD- 35
A USDWSL,K=USDESW*TABHL(USDWST,SPTHR,K,0,2,.2) PD- 36
T USDWST=.2/.2/.2/.35/.55/.8/.92/1/1.05/1.1/1.1 PD- 37
NOTE
NOTE USINT US INTENT
NOTE SPTHR SMOOTHED PERCEIVED THREAT
NOTE USURCF US URGENCY FACTOR
NOTE USDWSL US DESIRED WEAPON SYSTEMS LEVEL
NOTE
A BODSP,K=(PRESSF,K+CONGSF,K+PSDD,K)*USDWSL,K+ELYRM,K PD- 38
A PSDD,K=TABHL(POPST,QOL,K,0,3,.3) PD- 39

T	POPST=2.0/1.99/1.98/1.87/1.65/1.4/1.05/.85/.83/.8	PO- 40
C	POPSC=.1	PO- 41
NOTE		
NOTE	DODSP SUPPORT FOR DOD IN GENERAL	
NOTE	PSDD POPULAR SUPPORT FOR DOD	
NOTE	PRESSF PRESIDENTIAL SUPPORT FACTOR	
NOTE	CONCSF CONGRESSIONAL SUPPORT FACTOR	
NOTE	USDWSL US DESIRED WEAPON SYSTEMS LEVEL	
NOTE	ELYRM ELECTION YEAR MULTIPLIER	
NOTE		
A	NWSD,K=TABHL(NWSDT,NWSP,K,0,3,.3)*DODSP,K	PO- 42
T	NWSDT=.2/.2/.2/.33/.5/.72/.85/.94/1/1.05	PO- 43
A	NWSP,K=CWSF*CRPA,K+PWSF*PRPA,K	PO- 44
NOTE		
NOTE	NWSD NEW WEAPON SYSTEMS DESIRABILITY	
NOTE	NWSP NEW WEAPON SYSTEMS PERFORMANCE FACTOR	
NOTE	CWSF COST WEIGHTED SUPPORT FACTOR	
NOTE	PWSF PERFORMANCE WEIGHTED SUPPORT FACTOR	
NOTE	CRPA COST RATIO PLANNED TO ACTUAL	
NOTE	PRPA PERFORMANCE RATIO PLANNED TO ACTUAL	
NOTE		
A	GSPTRD,K(1)=TABHL(GSPTT1,NWSD,K,0,1,.1)	PO- 45
A	GSPTRD,K(2)=TABHL(GSPTT2,SPTHR,K,0,2,.2)	PO- 46
T	GSPTT1=.8/.82/.83/.85/.86/.91/.99/1.1/1.3/1.5/2.0	PO- 47
A	GSPTIN,K(1)=TABHL(GSPTT1,NWSD,K,0,1,.1)	PO- 48
A	GSPTIN,K(2)=TABHL(GSPTT2,SPTHR,K,0,2,.2)	PO- 49
T	GSPTT2=2.0/1.5/1.3/1.1/.99/.91/.86/.85/.83/.82/.81	PO- 50
A	GSPTOS,K(1)=TABHL(GSPTT1,NWSD,K,0,1,.1)	PO- 51
A	GSPTOS,K(2)=TABHL(GSPTT2,SPTHR,K,0,2,.2)	PO- 52
NOTE		
NOTE	GSPTRD GOVERNMENT SUPPORT FOR R&D PROGRAMS	
NOTE	GSPTIN GOVERNMENT SUPPORT FOR INVESTMENT	
NOTE	GSPTOS GOVERNMENT SUPPORT FOR O&S	
NOTE	SPTHR SMOOTHED PERCEIVED THREAT	
NOTE	NWSD NEW WEAPON SYSTEMS DESIRABILITY	
NOTE		
T	LOBBY=2/1.99/1.9/1.8/1.67/1.5/1.37/1.25/1.16/1.1	PO- 53
A	LPF,K=TABHL(LOBBY,CNPCR,JK/TCF,K,0,2,.2)*ABF	PO- 54
NOTE		
NOTE	LPF LOBBYIST PRESSURE FACTOR	
NOTE	CNPCR GNP GROWTH RATE	
NOTE	TCF TECHNICAL COMPLEXITY FACTOR	
NOTE	ABF AREA BENEFITS FACTOR	
NOTE		
C	CWSF=.7	PO- 55
C	PWSF=.3	PO- 56
NOTE		
NOTE	CWSF COST WEIGHTED SUPPORT FACTOR	
NOTE	PWSF PERFORMANCE WEIGHTED SUPPORT FACTOR	

NOTE NEED SECTOR *****

NOTE

FOR IN=1,120

N PLAN(IN)=0 ND- 1

NOTE

A USCAP.K(M0)=(WS0.K+WSN.K+WSP.K+SUMV(PLAN.K(*),1,T(M0)))* ND- 2

X USCPWS.K=LEF.K(M0)

A UADEF.K(M0)=ECAP.K(M0)-USCAP.K(M0)-ACAP.K(M0) ND- 3

A USDIF.K(M0)=MAX(0,UADEF.K(M0)+USDPCT.K) ND- 4

A USDEF.K(M0)=MAX(0,USDIF.K(M0)+USDESW) ND- 5

A USDPCT.K=1-ADPCT.K ND- 6

A USDEF.K(M0)=MAX(0,USDIF.K(M0)+USDESW) ND- 7

NOTE

NOTE USCAP US CAPABILITY

NOTE UADEF US/ALLIED COMBINED DEFICIENCY

NOTE USDIF US DIFFERENCE IN CAPABILITY

NOTE USDEF US DEFICIENCY

NOTE USDPCT PERCENT OF DEFICIENCY TO US

NOTE

A USURG.K=URGENCY(USDEF.K) ND- 8

A USURGF.K=TABLE(EWGT,USURG.K,0,120,10) ND- 9

NOTE

NOTE USURG US URGENCY--TIME IN MONTHS TIL FIRST DEFICIENCY

NOTE USURGF US URGENCY FACTOR

A RDSUPP.K(1)=SWITCH(0,RSUP1.K,RSUPAF.K(1)) ND- 10

A RDSUPP.K(2)=SWITCH(0,RSUP2.K,RSUPAF.K(2)) ND- 11

A INSUPP.K(1)=SWITCH(0,ISUP1.K,ISUPAF.K(1)) ND- 12

A INSUPP.K(2)=SWITCH(0,ISUP2.K,ISUPAF.K(2)) ND- 13

A OSSUPP.K(1)=SWITCH(0,OSUP1.K,OSUPAF.K(1)) ND- 14

A OSSUPP.K(2)=SWITCH(0,OSUP2.K,OSUPAF.K(2)) ND- 15

NOTE

NOTE RDSUPP R&D SUPPLEMENTAL REQUEST

NOTE INSUPP INVESTMENT SUPPLEMENTAL REQUEST

NOTE OSSUPP O&S SUPPLEMENTAL REQUEST

NOTE RSUP AMOUNT OF SUPPLEMENT FOR R&D

NOTE ISUP AMOUNT OF SUPPLEMENT FOR INVESTMENT

NOTE OSUP AMOUNT OF SUPPLEMENT FOR O&S

NOTE

R FP1INR.KL(1)=SWITCH(0,CNRD.K,DC4.K) ND- 16

R FP1INR.KL(2)=FYDPC*RDC ND- 17

R FP2INR.KL(1)=SWITCH(0,COST4.K,WSD3.K) ND- 18

R FP2INR.KL(2)=SWITCH(0,COST3.K+COST2.K,DC3.K+DC2.K) ND- 19

R FP3INR.KL(1)=NWSP.K*NCOST.K ND- 20

R FP3INR.KL(3)=FYDP3.K(2)*OSC ND- 21

NOTE

NOTE FP-INR INPUT RATES TO FIVE YEAR DEFENSE PLAN

NOTE CNRD COST FOR R&D ON NEW WEAPON SYSTEM

NOTE COST- COST FOR OPTION #-

NOTE DC- DECISION CONTROL FOR OPTION #-

NOTE FYDP3 O&S FUNDS REQUESTED IN THE FYDP

C FYDPC=1.E6 ND- 22

C USDESW=1.0 ND- 23

L PLAN.K(MO)=PLAN.J(MO)+DT*(PLADJ.JK(MO)) ND- 24

R PLADJ.KL(MO)=DNNWS.K+TABHL(SCHT,T(MO),0,120,12)*LTF.K(MO) ND- 25

A LTF.K(MO)=CLIP(1,0,T(MO),18) ND- 26

T SCHT=.03/.04/.08/.09/.11/.11/.11/.11/.11/.11 ND- 27

NOTE

NOTE PLAN PLANNED PFORCE LEVEL

NOTE PLADJ PLAN ADJUSTMENT RATE

NOTE LTF LEAD TIME FACTOR

NOTE T TIME TABLE

NOTE

NOTE

A NWSP.K=CLIP(SUM(DNWS.K),SUM(DNNWS.K),D4.K,D3.K) ND- 28

A RQNW.S.K=SUM(DNNWS.K) ND- 29

A VALT1.K=SUM(USDEF.K)/(ORDM*USCPWS.K) ND- 30

A VALT2.K=MODF.K ND- 31

A VALT3.K=NCPWS.K ND- 32

A VALT4.K=100 ND- 33

NOTE

NOTE VALT- VALUE OF ALTERNATIVE #-

NOTE MODF MODIFICATION FACTOR

NOTE NCPWS NEW CAPABILITY PER WEAPON SYSTEM

NOTE

A SCHF1.K=CLIP(0,1,SCHED1,USURG.K) ND- 34

C SCHED1=24 ND- 35

A SCHF2.K=CLIP(0,1,SCHED2,USURG.K) ND- 36

C SCHED2=48 ND- 37

A SCHF3.K=CLIP(0,1,SCHED3,USURG.K) ND- 38

C SCHED3=48 ND- 39

A SCHF4.K=CLIP(0,1,SCHED4,USURG.K) ND- 40

C SCHED4=08 ND- 41

NOTE

NOTE SCHF- SCHEDULE DECISION FACTOR FOR ALTERNATIVE #-

NOTE THIS VARIABLE DETERMINES IF TIME SS TOO SHORT

NOTE USURG US URGENCY

NOTE

A TFSL.K=(FYDP3.K(1)+FYDP3.K(2))/USCOST.K ND- 42

A COSTF1.K=CLIP(1,0,TFSL.K,COST1.K) ND- 43

A COSTF2.K=CLIP(1,0,TFSL.K,COST2.K) ND- 44

A COSTF3.K=CLIP(1,0,TFSL.K,COST3.K) ND- 45

A COSTF4.K=CLIP(1,0,TFSL.K,COST4.K) ND- 46

NOTE

NOTE COSTF- COST FACTOR FOR ALTERNATIVE #-

NOTE THIS VARIABLE DETERMINES IF COST IS WITHIN TOTAL FORCE LIMIT

NOTE IF NOT, PRESSURE MUST BE PUT ON TO RAISE FORCE LEVEL

NOTE

A DORR.K=(VALT1.K+WSO.K)/(WSO.K+WSN.K) ND- 47

A	NEWORR.K=MIN(1,DORR.K)	ND-	48
A	COST1.K=TABLE(CST1T,NEWORR.K,80,100,2)	ND-	49
A	D1.K=SCHF1.K*COSTF1.K	ND-	50
C	ORDM=.1	ND-	51
NOTE			
NOTE	DORR	DESIRED OR RATE	
NOTE	NEWORR	NEW OR RATE	
NOTE	COST1	COST OF ALTERNATIVE 1	
NOTE	D1	DECISION FOR ALTERNATIVE 1	
NOTE			
C	MODK=5	ND-	52
A	MODC.K=TABLE(MODFT,MODK,5,100,10)	ND-	53
A	MODF.K=SWITCH(0,MODC.K,D2.K)	ND-	54
A	NSYSM.K=MIN((WSO.K+WSN.K),SUM(USPTHR.K/VALT2.K))	ND-	55
A	COST2.K=TABLE(CST2T,NSYSM.K,0,100,10)	ND-	56
T	CST2T=0/100/200/300/400/500/600/700/800/900/1000	ND-	57
NOTE			
NOTE	MODK	MODIFICATION CONSTANT INCREASE IN CAPABILITY	
NOTE	MODC	MODIFICATION COST	
NOTE	MODF	MODIFICATION FACTOR	
NOTE	COST2	COST OF ALTERNATIVE 2	
NOTE	D2	DECISION FOR ALTERNATIVE 2	
NOTE			
A	D2.K=SCHF2.K*COSTF2.K	ND-	58
A	DNOWS.K(M0)=USDEF.K(M0)/VALT3.K	ND-	59
A	DNNWS.K(M0)=USDEF.K(M0)/VALT4.K	ND-	60
A	D3.K=SCHF3.K*COSTF3.K	ND-	61
A	D4.K=SCHF3.K*COSTF3.K	ND-	62
NOTE			
NOTE	DNOWS	DESIRED NUMBER OF OLD WEAPONS SYSTEMS	
NOTE	DNNWS	DESIRED NUMBER OF NEW WEAPON SYSTEMS	
NOTE	D3	DECISION FOR ALTERNATIVE 3	
NOTE	D4	DECISION FOR ALTERNATIVE 4	
NOTE			
A	COST3.K=SUM(DNOWS.K)*USCOST.K*AGEM.K	ND-	63
A	AGEM.K=TABLE(AGFT,TIME.K,0,20,10)	ND-	64
A	COST4.K=DNNWS.K*PC1.K	ND-	65
NOTE			
NOTE	AGEM	AGE MULTIPLIER	
NOTE	COST3	COST OF ALTERNATIVE 3	
NOTE	COST4	COST OF ALTERNATIVE 4	
NOTE			

NOTE NEED SECTOR *****

NOTE

FOR IN=1,120

N PLAN(IN)=0 ND- 1

NOTE

A $USCAP.K(MO) = (WSQ.K + WSN.K + WSP.K + SUMV(PLAN.K(*), 1, T(MO))) +$ ND- 2

X $USCPWS.K * LEF.K(MO)$

A $UADEF.K(MO) = ECAP.K(MO) - USCAP.K(MO) - ACAP.K(MO)$ ND- 3

A $USDIF.K(MO) = MAX(0, UADEF.K(MO) * USDPCT.K)$ ND- 4

A $USDEF.K(MO) = MAX(0, USDIF.K(MO) * USDESW)$ ND- 5

A $USDPCT.K = 1 - ADPCT.K$ ND- 6

A $USDEF.K(MO) = MAX(0, USDIF.K(MO) * USDESW)$ ND- 7

NOTE

NOTE USCAP US CAPABILITY

NOTE UADEF US/ALLIED COMBINED DEFICIENCY

NOTE USDIF US DIFFERENCE IN CAPABILITY

NOTE USDEF US DEFICIENCY

NOTE USDPCT PERCENT OF DEFICIENCY TO US

NOTE

A $USURC.K = URGENCY(USDEF.K)$ ND- 8

A $USURCF.K = TABLE(EMGT, USURC.K, 0, 120, 10)$ ND- 9

NOTE

NOTE USURC US URGENCY--TIME IN MONTHS TIL FIRST DEFICIENCY

NOTE USURCF US URGENCY FACTOR

A $RDSUPP.K(1) = SWITCH(0, RSUP1.K, RSUPAF.K(1))$ ND- 10

A $RDSUPP.K(2) = SWITCH(0, RSUP2.K, RSUPAF.K(2))$ ND- 11

A $INSUPP.K(1) = SWITCH(0, ISUP1.K, ISUPAF.K(1))$ ND- 12

A $INSUPP.K(2) = SWITCH(0, ISUP2.K, ISUPAF.K(2))$ ND- 13

A $OSSUPP.K(1) = SWITCH(0, OSUP1.K, OSUPAF.K(1))$ ND- 14

A $OSSUPP.K(2) = SWITCH(0, OSUP2.K, OSUPAF.K(2))$ ND- 15

NOTE

NOTE RDSUPP R&D SUPPLEMENTAL REQUEST

NOTE INSUPP INVESTMENT SUPPLEMENTAL REQUEST

NOTE OSSUPP O&S SUPPLEMENTAL REQUEST

NOTE RSUP AMOUNT OF SUPPLEMENT FOR R&D

NOTE ISUP AMOUNT OF SUPPLEMENT FOR INVESTMENT

NOTE OSUP AMOUNT OF SUPPLEMENT FOR O&S

NOTE

R $FP1INR.KL(1) = SWITCH(0, CNRD.K, DC4.K)$ ND- 16

R $FP1INR.KL(2) = FYDPC * RDC$ ND- 17

R $FP2INR.KL(1) = SWITCH(0, COST4.K, WSD3.K)$ ND- 18

R $FP2INR.KL(2) = SWITCH(0, COST3.K + COST2.K, DC3.K + DC2.K)$ ND- 19

R $FP3INR.KL(1) = NWSP.K + NCOST.K$ ND- 20

R $FP3INR.KL(3) = FYDP3.K(2) + OSC$ ND- 21

NOTE

NOTE FP-INR INPUT RATES TO FIVE YEAR DEFENSE PLAN

NOTE CNRD COST FOR R&D ON NEW WEAPON SYSTEM

NOTE COST- COST FOR OPTION #-

NOTE DC- DECISION CONTROL FOR OPTION #-

NOTE FYDP3 O&S FUNDS REQUESTED IN THE FYDP

C FYDPC=1.E6 ND- 22

C USDESW=1.0 ND- 23

L PLAN.K(MO)=PLAN.J(MO)+DT*(PLADJ.JK(MO)) ND- 24

R PLADJ.KL(MO)=DNNWS.K+TABHL(SCHT,T(MO),0,120,12)*LTF.K(MO) ND- 25

A LTF.K(MO)=CLIP(1,0,T(MO),18) ND- 26

T SCHT=.03/.04/.08/.09/.11/.11/.11/.11/.11/.11 ND- 27

NOTE

NOTE PLAN PLANNED PFORCE LEVEL

NOTE PLADJ PLAN ADJUSTMENT RATE

NOTE LTF LEAD TIME FACTOR

NOTE T TIME TABLE

NOTE

A NWSP.K=CLIP(SUM(DNWS.K),SUM(DNNWS.K),D4.K,D3.K) ND- 28

A RQNWS.K=SUM(DNNWS.K) ND- 29

A VALT1.K=SUM(USDEF.K)/(ORDM*USCPWS.K) ND- 30

A VALT2.K=MODF.K ND- 31

A VALT3.K=NCPWS.K ND- 32

A VALT4.K=100 ND- 33

NOTE

NOTE VALT- VALUE OF ALTERNATIVE #-

NOTE MODF MODIFICATION FACTOR

NOTE NCPWS NEW CAPABILITY PER WEAPON SYSTEM

NOTE

A SCHF1.K=CLIP(0,1,SCHED1,USURG.K) ND- 34

C SCHED1=24 ND- 35

A SCHF2.K=CLIP(0,1,SCHED2,USURG.K) ND- 36

C SCHED2=48 ND- 37

A SCHF3.K=CLIP(0,1,SCHED3,USURG.K) ND- 38

C SCHED3=48 ND- 39

A SCHF4.K=CLIP(0,1,SCHED4,USURG.K) ND- 40

C SCHED4=08 ND- 41

NOTE

NOTE SCHF- SCHEDULE DECISION FACTOR FOR ALTERNATIVE #-

NOTE THIS VARIABLE DETERMINES IF TIME SS TOO SHORT

NOTE USURG US URGENCY

NOTE

A TFSL.K=(FYDP3.K(1)+FYDP3.K(2))/USCOST.K ND- 42

A COSTF1.K=CLIP(1,0,TFSL.K,COST1.K) ND- 43

A COSTF2.K=CLIP(1,0,TFSL.K,COST2.K) ND- 44

A COSTF3.K=CLIP(1,0,TFSL.K,COST3.K) ND- 45

A COSTF4.K=CLIP(1,0,TFSL.K,COST4.K) ND- 46

NOTE

NOTE COSTF- COST FACTOR FOR ALTERNATIVE #-

NOTE THIS VARIABLE DETERMINES IF COST IS WITHIN TOTAL FORCE LIMIT

NOTE IF NOT, PRESSURE MUST BE PUT ON TO RAISE FORCE LEVEL

NOTE

A DORR.K=(VALT1.K+WSO.K)/(WSO.K+WSN.K) ND- 47

A	NEWORR.K=MIN(1,DORR.K)	ND-	48
A	COST1.K=TABLE(CST1T,NEWORR.K,80,100,2)	ND-	49
A	D1.K=SCHF1.K*COSTF1.K	ND-	50
C	ORDM=.1	ND-	51
NOTE			
NOTE	DORR	DESIRED OR RATE	
NOTE	NEWORR	NEW OR RATE	
NOTE	COST1	COST OF ALTERNATIVE 1	
NOTE	D1	DECISION FOR ALTERNATIVE 1	
NOTE			
C	MODK=5	ND-	52
A	MODC.K=TABLE(MODFT,MODK,0,100,10)	ND-	53
A	MODF.K=SWITCH(0,MODC.K,D2.K)	ND-	54
A	NSYSM.K=MIN((WSO.K+WSN.K),SUM(USPTHR.K/VALT2.K))	ND-	55
A	COST2.K=TABLE(CST2T,NSYSM.K,0,100,10)	ND-	56
T	CST2T=0/100/200/300/400/500/600/700/800/900/1000	ND-	57
NOTE			
NOTE	MODK	MODIFICATION CONSTANT INCREASE IN CAPABILITY	
NOTE	MODC	MODIFICATION COST	
NOTE	MODF	MODIFICATION FACTOR	
NOTE	COST2	COST OF ALTERNATIVE 2	
NOTE	D2	DECISION FOR ALTERNATIVE 2	
NOTE			
A	D2.K=SCHF2.K*COSTF2.K	ND-	58
A	DNOWS.K(MO)=USDEF.K(MO)/VALT3.K	ND-	59
A	DNNWS.K(MO)=USDEF.K(MO)/VALT4.K	ND-	60
A	D3.K=SCHF3.K*COSTF3.K	ND-	61
A	D4.K=SCHF3.K*COSTF3.K	ND-	62
NOTE			
NOTE	DNOWS	DESIRED NUMBER OF OLD WEAPONS SYSTEMS	
NOTE	DNNWS	DESIRED NUMBER OF NEW WEAPON SYSTEMS	
NOTE	D3	DECISION FOR ALTERNATIVE 3	
NOTE	D4	DECISION FOR ALTERNATIVE 4	
NOTE			
A	COST3.K=SUM(DNOWS.K)*USCOST.K*AGEM.K	ND-	63
A	AGEM.K=TABLE(AGFT,TIME.K,0,20,10)	ND-	64
A	COST4.K=DNNWS.K*PC1.K	ND-	65
NOTE			
NOTE	AGEM	AGE MULTIPLIER	
NOTE	COST3	COST OF ALTERNATIVE 3	
NOTE	COST4	COST OF ALTERNATIVE 4	
NOTE			

NOTE FINANCIAL SECTOR

NOTE

NOTE ***** BUDGET SECTION *****

NOTE

FOR IB=1,2

N RDRB(IB)=0 FN- 1

N IDRB(IB)=0 FN- 2

N ODRB(IB)=0 FN- 3

N DDRB(IB)=0 FN- 4

C FYDPC=1.E6 FN- 5

NOTE

L RDRB.K(IB)=RDRB.J(IB)+DT*(RDMDR.JK(IB)-RREDR.JK(IB)) FN- 6

R RDMDR.KL(IB)=RDRQT.K(IB)+RDSUPP.K(IB) FN- 7

R RREDR.KL(IB)=RDAR.JK(IB) FN- 8

NOTE

NOTE RDRB R&D DOLLARS REQUESTED IN THE BUDGET

NOTE RDMDR R&D DEMAND RATE

NOTE RREDR R&D DEMAND REDUCTION RATE

NOTE RDRQT R&D FUNDS REQUIREMENT

NOTE RDAR R&D ALLOCATION RATE

NOTE RDSUPP R&D SUPPLEMENTAL REQUEST

NOTE

A PRDD.K(IB)=GSPTRD.K(IB)+RDRB.K(IB) FN- 9

NOTE

NOTE PRDD PRESSURE FOR R&D DOLLARS

NOTE GSPTRD GOVERNMENT SUPPORT FOR R&D

NOTE RDRB R&D DOLLARS REQUESTED IN THE BUDGET

NOTE

L IDRB.K(IB)=IDRB.J(IB)+DT*(IDMDR.JK(IB)-IREDR.JK(IB)) FN- 10

R IDMDR.KL(IB)=IRQT.K(IB)+INSUPP.K(IB) FN- 11

R IREDR.KL(IB)=IDAR.JK(IB) FN- 12

NOTE

NOTE IDRB INVESTMENT DOLLARS REQUESTED IN THE BUDGET

NOTE IDMDR INVESTMENT DEMAND RATE

NOTE IREDR INVESTMENT DEMAND REDUCTION RATE

NOTE IRQT INVESTMENT FUNDS REQUIREMENT

NOTE IDAR INVESTMENT ALLOCATION RATE

NOTE INSUPP INVESTMENT SUPPLEMENTAL REQUEST

NOTE

A PID.K(IB)=GSPTIN.K(IB)+IDRB.K(IB) FN- 13

NOTE

NOTE PID PRESSURE FOR INVESTMENT DOLLARS

NOTE GSPTIN GOVERNMENT SUPPORT FOR INVESTMENT

NOTE IDRB INVESTMENT DOLLARS REQUESTED IN THE BUDGET

NOTE

L ODRB.K(IB)=ODRB.J(IB)+DT*(ODMDR.JK(IB)-ORED.R.JK(IB)) FN- 14

R ODMDR.KL(IB)=ORQT.K(IB)+OSSUPP.K(IB) FN- 15

R OREDR.KL(IB)=OSDAR.JK(IB) FN- 16

NOTE

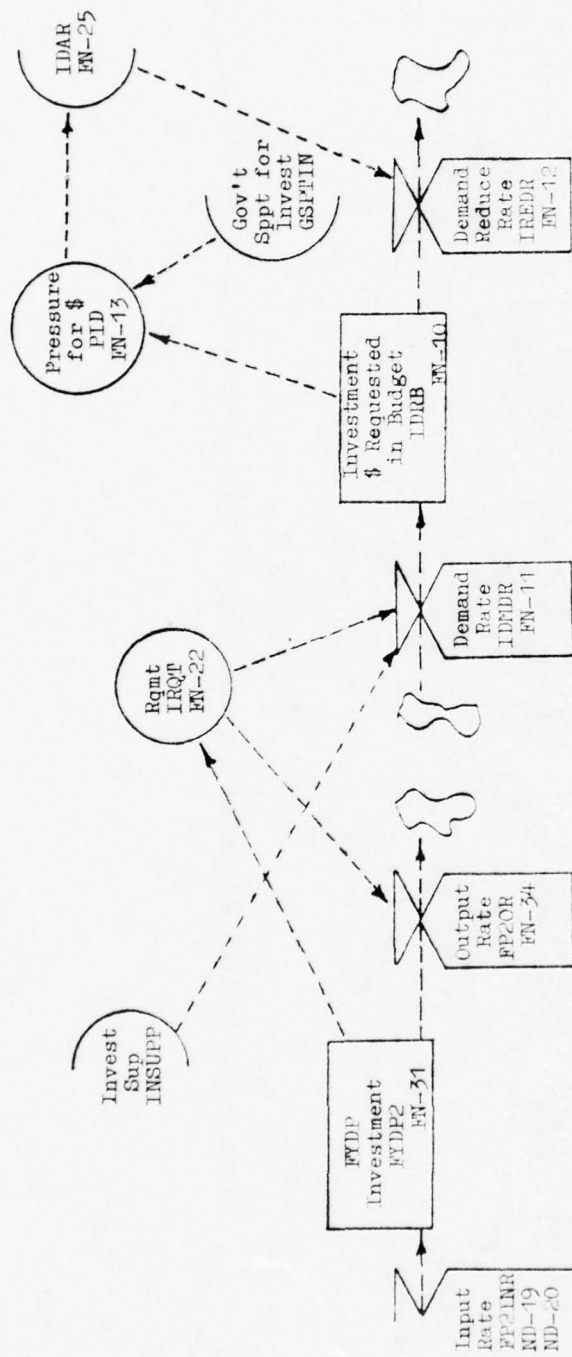


Figure C-1
Financial Sector--Investment Programming and Budgeting

NOTE ODRB O&S DOLLARS REQUESTED IN THE BUDGET
 NOTE ODMDR O&S DEMAND RATE
 NOTE OREDR O&S DEMAND REDUCTION RATE
 NOTE ORQT O&S FUNDS REQUIREMENT
 NOTE OSDAR O&S ALLOCATION RATE
 NOTE OSSUPP O&S SUPPLEMENTAL REQUEST
 NOTE
 A $POSD.K(IB) = GSPTOS.K(IB) * ODRB.K(IB)$ FN- 17
 NOTE
 NOTE POSD PRESSURE FOR O&S DOLLARS
 NOTE GSPTOS GOVERNMENT SUPPORT FOR O&S
 NOTE ODRB O&S DOLLARS REQUESTED IN THE BUDGET
 NOTE
 L $DDR.B.K(IB) = DDR.B.J(IB) + DT * (DDMDR.JK(IB) - DREDR.JK(IB))$ FN- 18
 R $DDMDR.KL(IB) = RDRQT.K(IB) + IRQT.K(IB) + ORQT.K(IB)$ FN- 19
 R $DREDR.KL(IB) = RDAR.JK(IB) + IDAR.JK(IB) + OSDAR.JK(IB)$ FN- 20
 NOTE
 NOTE DDRB DEFENSE DOLLARS REQUESTED IN THE BUDGET
 NOTE DDMDR DEFENSE DEMAND RATE
 NOTE DREDR DEFENSE DEMAND REDUCTION RATE
 NOTE RDRQT R&D FUNDS REQUIREMENT
 NOTE IRQT INVESTMENT FUNDS REQUIREMENT
 NOTE ORQT O&S FUNDS REQUIREMENT
 NOTE RDAR R&D ALLOCATION RATE
 NOTE IDAR INVESTMENT ALLOCATION RATE
 NOTE OSDAR O&S ALLOCATION RATE
 NOTE
 A $RDRQT.K(IB) = FYDP1.K(IB) * PULSE(1,11,12)$ FN- 21
 NOTE
 NOTE RDRQT R&D FUNDS REQUIREMENT
 NOTE FYDP1 R&D EXPENDITURES PLANNED IN THE FYDP
 NOTE
 A $IRQT.K(IB) = FYDP2.K(IB) * PULSE(1,11,12)$ FN- 22
 NOTE
 NOTE IRQT INVESTMENT FUNDS REQUIREMENT
 NOTE FYDP2 INVESTMENT EXPENDITURES PLANNED IN THE FYDP
 NOTE
 A $ORQT.K(IB) = FYDP3.K(IB) * PULSE(1,11,12)$ FN- 23
 NOTE
 NOTE ORQT O&S FUNDS REQUIREMENT
 NOTE FYDP3 O&S EXPENDITURES PLANNED IN THE FYDP
 NOTE
 R $RDAR.KL(IB) = PRDD.K(IB) * PULSE(1,10,12)$ FN- 24
 NOTE
 NOTE RDAR R&D APPROPRIATION RATE
 NOTE PRDD PRESSURE FOR R&D DOLLARS
 NOTE
 R $IDAR.KL(IB) = PID.K(IB) * PULSE(1,10,12)$ FN- 25
 NOTE

NOTE IDAR INVESTMENT APPROPRIATION RATE
 NOTE PID PRESSURE FOR INVESTMENT DOLLARS
 NOTE
 R OSDAR.KL(IB)=POSD.K(IB)*PULSE(1,10,12) FN- 26
 NOTE
 NOTE OSDAR O&S APPROPRIATION RATE
 NOTE POSD PRESSURE FOR O&S DOLLARS
 NOTE
 N FYDP1(IB)=0 FN- 27
 N FYDP2(IB)=0 FN- 28
 N FYDP3(IB)=0 FN- 29
 NOTE
 NOTE FYDP FIVE YEAR DEFENSE PLAN
 NOTE
 L FYDP1.K(IB)=FYDP1.J(IB)+DT*(FP11NR.JK(IB)-FP10R.JK(IB)) FN- 30
 R FP10R.KL(IB)=RDRQT.K(IB) FN- 31
 NOTE
 NOTE FYDP1 R&D EXPENDITURES PLANNED IN THE FYDP
 NOTE FP11NR R&D COSTS INPUT TO THE FYDP
 NOTE FP10R R&D COSTS FUNDED FROM THE FYDP
 NOTE RDRQT R&D FUNDS REQUIREMENT
 NOTE
 L FYDP2.K(IB)=FYDP2.J(IB)+DT*(FP21NR.JK(IB)-FP20R.JK(IB)) FN- 32
 R FP20R.KL(IB)=IRQT.K(IB) FN- 33
 NOTE
 NOTE FYDP2 INVESTMENT EXPENDITURES PLANNED IN THE FYDP
 NOTE FP21NR INVESTMENT COSTS INPUT TO THE FYDP
 NOTE FP20R INVESTMENT COSTS FUNDED FROM THE FYDP
 NOTE IRQT INVESTMENT FUNDS REQUIREMENT
 NOTE
 L FYDP3.K(IB)=FYDP3.J(IB)+DT*(FP31NR.JK(IB)-FP30R.JK(IB)) FN- 34
 R FP30R.KL(IB)=ORQT.K(IB) FN- 35
 NOTE
 NOTE FYDP3 O&S EXPENDITURES PLANNED IN THE FYDP
 NOTE FP31NR O&S COSTS INPUT TO THE FYDP
 NOTE FP30R O&S COSTS FUNDED FROM THE FYDP
 NOTE ORQT O&S FUNDS REQUIREMENT
 NOTE
 NOTE FINANCIAL ALLOCATION AND EXPENSES
 NOTE
 FOR PROJ=1,2
 L RDA.K(PROJ)=RDA.J(PROJ)+DT*(RDAR.JK(PROJ)-RDOR.JK(PROJ)) FN- 36
 X +RRPR.JK(PROJ))
 N RDA(1)=RDA1C FN- 37
 C RDA1C=0 FN- 38
 N RDA(2)=RDA2C FN- 39
 N RDA2C=0 FN- 40
 NOTE RDA RESEARCH DOLLARS APPROPRIATED
 NOTE RDAR RESEARCH DOLLAR APPROPRIATION RATE

R	RDPR.KL(2)=DELAY3(RDOR.JK(2),RDPR2D)	FN- 60
C	RDPR2D=48	FN- 61
NOTE	RDPR RESEARCH DOLLARS PAYMENT RATE	
NOTE	RDOR RESEARCH DOLLAR OBLIGATION RATE	
NOTE	RDPR2D RESEARCH DOLLAR PAYMENT RATE DELAY	
NOTE		
NOTE		
NOTE	INVESTMENT COSTS	
NOTE		
L	IDA.K(PROJ)=IDA.J(PROJ)+DT*(IDAR.JK(PROJ)-IDOR.JK(PROJ)	FN- 62
X	+IRPR.JK(PROJ))	
N	IDA(1)=IDA1C	FN- 63
C	IDA1C=0	FN- 64
N	IDA(2)=IDA2C	FN- 65
C	IDA2C=0	FN- 66
NOTE	IDA INVESTMENT DOLLARS APPROPRIATED	
NOTE	IDAR INVESTMENT DOLLARS APPROPRIATION RATE	
NOTE	IDOR INVESTMENT DOLLARS OBLIGATION RATE	
NOTE	IRPR INVESTMENT REPROGRAMMING RATE	
R	IRPR.KL(1)=CPC4.K	FN- 67
R	IRPR.KL(2)=-CPC4.K	FN- 68
NOTE	IRPR INVESTMENT REPROGRAMMING RATE	
NOTE	CPC4 CHANGE IN PLANNED COSTS	
A	IPF.K=SWITCH(0,1,IDA.K(1))	FN- 69
NOTE	IPF INVESTMENT PROGRAM FUNDING	
NOTE	IDA INVESTMENT DOLLARS APPROPRIATED	
NOTE		
R	IDOR.KL(1)=TPIC.K*IDOSWI.K	FN- 70
NOTE	IDOR INVESTMENT DOLLARS OBLIGATION RATE	
NOTE	TPIC TOTAL PLANNED COSTS	
NOTE	IDOSWI INVESTMENT DOLLARS OBLIGATION SWITCH	
A	TPIC.K=TPC4.K+WSD4.K*DSWI4.K+CPC4.K	FN- 71
NOTE	TPIC TOTAL PLANNED INVESTMENT COSTS	
NOTE	TPC4 TOTAL PLANNED COSTS	
NOTE	WSD WEAPON SYSTEM DEVELOPMENT DECISION	
NOTE	DSWI4 DOLLAR SWITCH 4	
NOTE	CPC CHANGE IN PLANNED COSTS	
A	IDOSWI.K(PROJ)=SWITCH(0,1,IDA.K(PROJ))	FN- 72
NOTE	IDOSWI INVESTMENT DOLLARS OBLIGATION SWITCH	
NOTE	IDA INVESTMENT DOLLARS APPROPRIATED	
R	IDOR.KL(2)=IDA.K(2)*APRF.K*IDOSWI.K(2)	FN- 73
NOTE	IDOR INVESTMENT DOLLARS OBLIGATED FOR OTHER	
NOTE	IDA INVESTMENT DOLLARS APPROPRIATED FOR OTHER	
NOTE	APRF APPROPRIATION RATE FRACTION	
NOTE	IDOSWI INVESTMENT DOLLARS OBLIGATION SWITCH	
L	IDOC.K(PROJ)=IDOC.J(PROJ)+DT*(IDOR.JK(PROJ)-IDPR.JK(PROJ))	FN- 74
N	IDOC(1)=IDOC1C	FN- 75
C	IDOC1C=0	FN- 76

NOTE RDOR RESEARCH DOLLARS OBLIGATION RATE
 NOTE RRPR RESEARCH REPROGRAMMING RATE
 R $RRPR.KL(1) = CPC1.K + CPC2.K + CPC3.K$ FN- 41
 R $RRPR.KL(2) = -(CPC1.K + CPC2.K + CPC3.K)$ FN- 42
 NOTE RRPR RESEARCH REPROGRAMMING RATE
 NOTE CPC CHANGE IN PLANNED COSTS
 A $RPF.K = SWITCH(0, 1, RDA.K(1))$ FN- 43
 NOTE RPF RESEARCH PROGRAM FUNDING
 NOTE RDA RESEARCH DOLLAR APPROPRIATED
 R $RDOR.KL(1) = TPRC.K + RDOSWI.K(1)$ FN- 44
 NOTE RDOR RESEARCH DOLLARS OBLIGATION RATE
 NOTE TPRC TOTAL PLANNED RESEARCH COSTS
 NOTE RDOSWI RESEARCH DOLLARS OBLIGATION SWITCH
 A $TPRC.K = TPC01.K + TPC02.K + TPC03.K$ FN- 45
 A $TPC01.K = (TPC1.K + WSD1.K + DSWI1.K) + CPC1.K$ FN- 46
 A $TPC02.K = TPC2.K + WSD2.K + DSWI2.K + CPC2.K$ FN- 47
 A $TPC03.K = TPC3.K + WSD3.K + DSWI3.K + CPC3.K$ FN- 48
 NOTE TPRC TOTAL PLANNED RESEARCH COSTS
 NOTE TPC0 TOTAL PLANNED COST OBLIGATED
 NOTE WSD WEAPON SYSTEM DEVELOPMENT DECISION
 NOTE DSWI DOLLAR SWITCH
 NOTE CPC CHANGE IN PLANNED COSTS
 A $RDOSWI.K(PROJ) = SWITCH(0, 1, RDA.K(PROJ))$ FN- 49
 NOTE RDOSWI RESEARCH DOLLARS OBLIGATION SWITCH
 NOTE RDA RESEARCH DOLLAR APPROPRIATED
 R $RDOR.KL(2) = (RDA.K(2) * APRF.K) + RDOSWI.K(2)$ FN- 50
 NOTE RDOR RESEARCH DOLLARS OBLIGATION RATE
 NOTE RDOSWI RESEARCH DOLLARS OBLIGATION SWITCH
 A $APRF.K = TABLE(APRFT, FYTIME.K, 1, 12, 1)$ FN- 51
 T $APRFT = 1.0/.5/.33/.25/.2/.167/.143/.125/.111/.1/.09/.083$ FN- 52
 NOTE APRF APPROPRIATION RATE FRACTION
 NOTE FYTIME FISCAL YEAR TIME
 N $RDOC(1) = RDOC1C$ FN- 53
 C $RDOC1C = 0$ FN- 54
 N $RDOC(2) = RDOC2C$ FN- 55
 C $RDOC2C = 0$ FN- 56
 NOTE RDOC RESEARCH DOLLARS ON CONTRACT
 NOTE RDOR RESEARCH DOLLARS OBLIGATION RATE
 NOTE RDPR RESEARCH DOLLAR PAYMENT RATE
 R $RDPR.KL(1) = RDPSWI.K(1) * (DELAY3(CRR1.JK, RDPRD) + DELAY3(CRR2.JK, FN- 57$
 X $+ RDPRD) + DELAY3(CRR3.JK, RDPRD))$
 C $RDPRD = 3$ FN- 58
 NOTE RDPR RESEARCH DOLLARS PAYMENT RATE
 NOTE RDPSWI RESEARCH DOLLARS PAYMENT SWITCH
 NOTE CRR COST REPORTING RATE
 NOTE RDPRD RESEARCH DOLLARS PAYMENT RATE DELAY
 A $RDPSWI.K(PROJ) = SWITCH(0, 1, RDOC.K(PROJ))$ FN- 59
 NOTE RDPSWI RESEARCH DOLLARS PAYMENT SWITCH
 NOTE RDOC RESEARCH DOLLARS ON CONTRACT

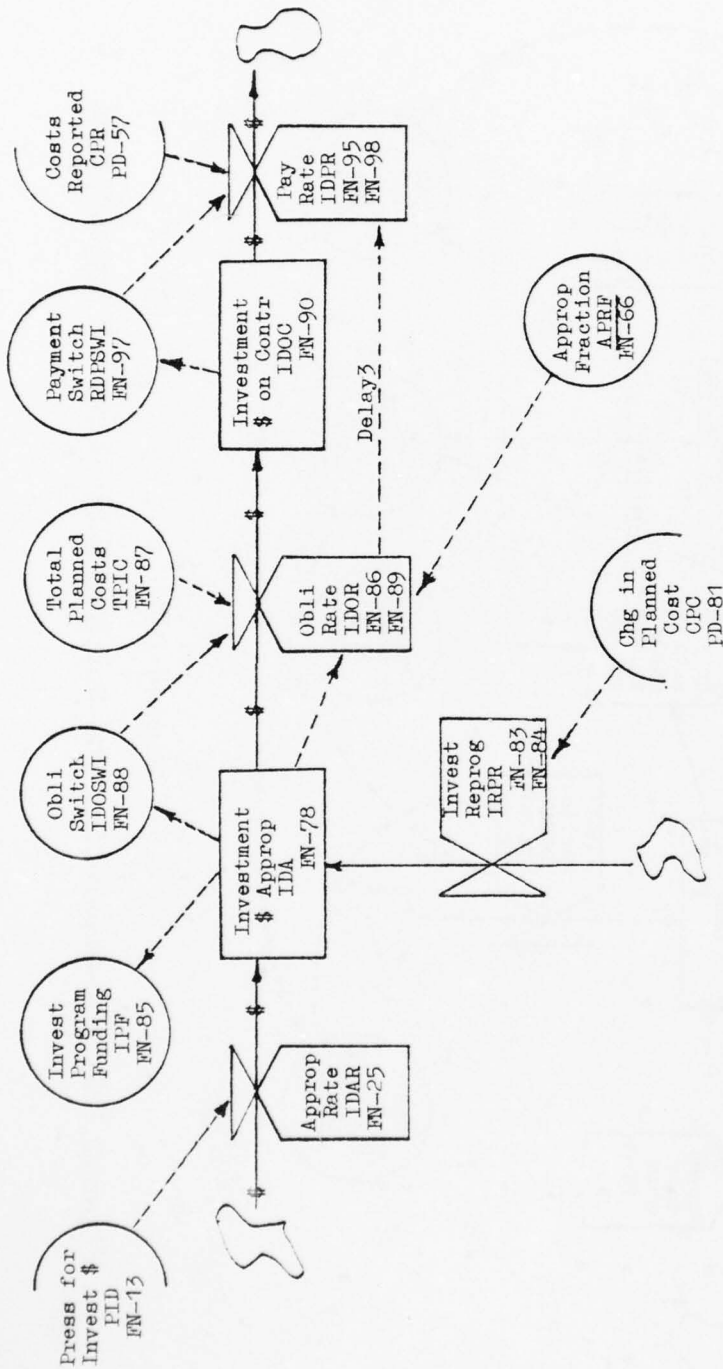


Figure C-3
Financial Sector--Investment Allocation and Expenditure

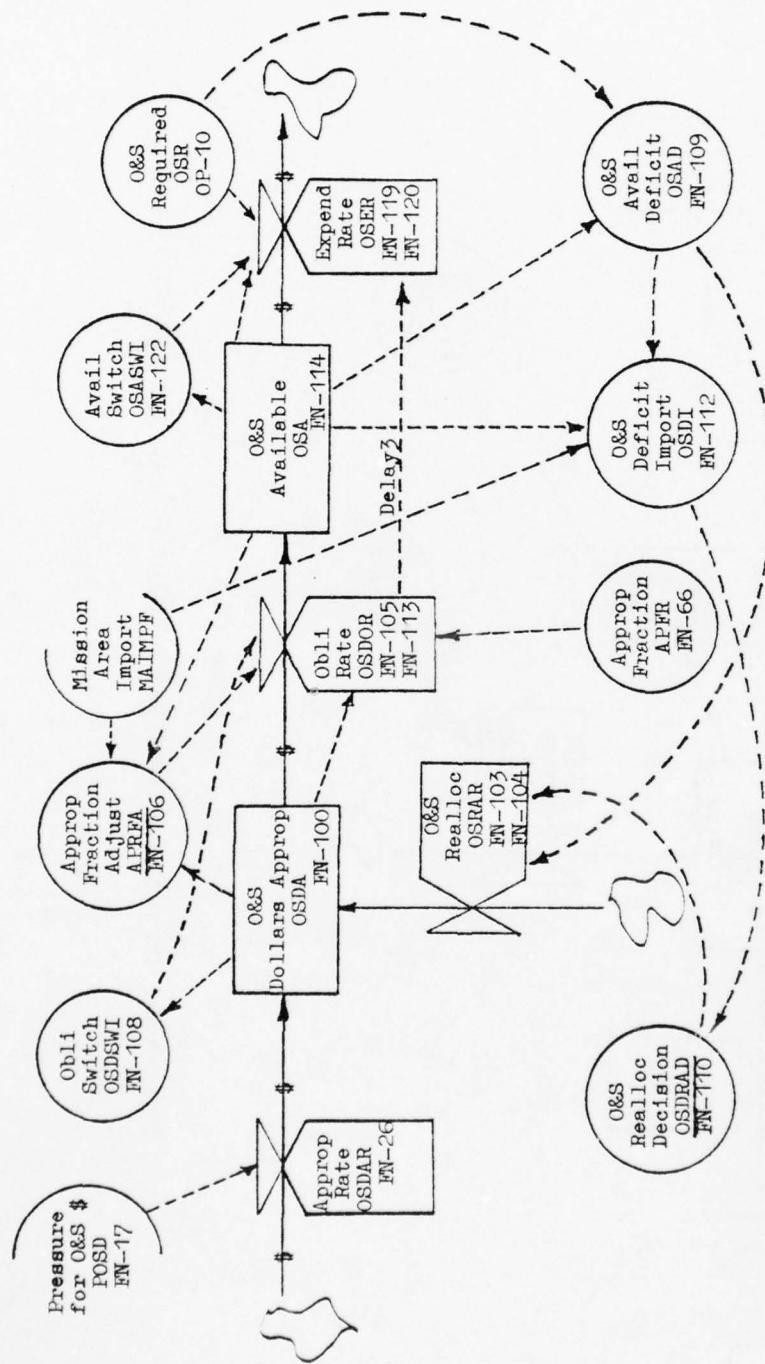


Figure C-4
Financial Sector--Operating and Support Allocation and Expenditure

A	OSAD.K=MAX(OSR.K-OSA.K(1),0)	FN- 93
NOTE	OSAD O&S AVAILABLE DEFICIT	
NOTE	OSR O&S REQUESTED	
NOTE	OSA O&S AVAILABLE	
A	OSDRAD.K=TABHL(OSDRAT,OSDI.K,0,10,1)	FN- 94
T	OSDRAT=1.0/1.0/.9/.66/.42/.2/.3/.01/0.0/0.0/0.0	FN- 95
NOTE	OSDRAD O&S DOLLARS REALLOCATION DECISION	
NOTE	OSDI O&S DEFICIT IMPORTANCE	
A	OSDI.K=OSAD.K/OSA.K(2)+1/MAIMPF	FN- 96
NOTE	OSDI O&S DEFICIT IMPORTANCE	
NOTE	OSAD O&S AVAILABLE DEFICIT	
NOTE	OSA O&S AVAILABLE	
NOTE	MAIMPF MISSION AREA IMPORTANCE FACTOR	
R	OSDOR.KL(2)=OSDA.K(2)*APRF.K*OSDSWI.K(2)	FN- 97
NOTE	OSDOR O&S DOLLAR OBLIGATION RATE	
NOTE	OSDA O&S DOLLARS APPROPRIATED	
NOTE	APRF APPROPRIATION FRACTION	
NOTE	OSDSWI O&S DOLLARS SWITCH	
L	OSA.K(PROJ)=OSA.J(PROJ)+DT*(OSDOR.JK(PROJ)-OSER.JK(PROJ))	FN- 98
N	OSA(1)=OSA1C	FN- 99
C	OSA1C=0	FN- 100
N	OSA(2)=OSA2C	FN- 101
C	OSA2C=0	FN- 102
NOTE	OSA O&S AVAILABLE	
NOTE	OSDOR O&S DOLLARS OBLIGATION RATE	
NOTE	OSER O&S EXPENSE RATE	
R	OSER.KL(1)=MIN(OSR.K,OSA.K(1))+OSASWI.K(1)	FN- 103
NOTE	OSER O&S EXPENSE RATE	
NOTE	OSR O&S REQUESTED	
NOTE	OSA O&S AVAILABLE	
NOTE	OSASWI O&S AVAILABLE SWITCH	
R	OSER.K(2)=DELAY3(OSDOR.KL(2),OSERD)	FN- 104
C	OSERD=1	FN- 105
NOTE	OSER O&S EXPENSE RATE	
NOTE	OSDOR O&S DOLLAR OBLIGATION RATE	
NOTE	OSERD O&S EXPENSE REPORTING DELAY	
A	OSASWI.K(PROJ)=SWITCH(0,1,OSA.K(PROJ))	FN- 106
NOTE	OSASWI O&S AVAILABLE SWITCH	
NOTE	OSA O&S AVAILABLE	
NOTE	APRF APPROPRIATION FRACTION	

N IDOC(2)=IDOC2C FN- 77
 C IDOC2C=0 FN- 78
 NOTE IDOC INVESTMENT DOLLARS ON CONTRACT
 NOTE IDOR INVESTMENT DOLLARS OBLIGATION RATE
 NOTE IDPR INVESTMENT DOLLARS PAYMENT RATE
 R IDPR.KL(1)=IDPSWI.K(1)*DELAY3(CRR4.JK,IDPRD) FN- 79
 C IDPRD=3 FN- 80
 NOTE IDPR INVESTMENT DOLLAR PAYMENT RATE FOR PROJECT
 NOTE IDPSWI INVESTMENT DOLLARS PAYMENT SWITCH
 NOTE CRR4 COST REPORTING RATE 4
 NOTE IDPRD INVESTMENT DOLLARS PAYMENT RATE DELAY
 A IDPSWI.K(PROJ)=SWITCH(0,1,IDOC.K(PROJ)) FN- 81
 NOTE IDPSWI INVESTMENT DOLLAR PAYMENT SWITCH
 NOTE IDOC INVESTMENT DOLLARS ON CONTRACT
 R IDPR.KL(2)=DELAY3(IDOR.JK(2),IDPR2D) FN- 82
 C IDPR2D=24 FN- 83
 NOTE IDPR INVESTMENT DOLLAR PAYMENT RATE FOR OTHER
 NOTE IDOR INVESTMENT DOLLARS OBLIGATION RATE
 NOTE IDPR2D INVESTMENT DOLLAR PAYMENT RATE DELAY
 NOTE
 NOTE
 NOTE OPERATING AND SUPPORT COSTS
 NOTE
 L OSDA.K(PROJ)=OSDA.J(PROJ)=DT*(OSDAR.JK(PROJ)-OSDOR.JK(PROJ) FN- 84
 X +OSRAR.JK(PROJ)
 N OSDA=OSDAC FN- 85
 C OSDAC=0 FN- 86
 NOTE OSDA O&S DOLLARS APPROPRIATED
 NOTE OSDAR O&S DOLLARS APPROPRIATION RATE
 NOTE OSDOR O&S DOLLARS OBLIGATION RATE
 NOTE OSRAR O&S REALLOCATION RATE
 R OSRAR.KL(1)=OSAD.K+OSDRAD.K FN- 87
 R OSRAR.KL(2)=- (OSAD.K+OSDRAD.K) FN- 88
 NOTE OSRAR O&S REALLOCATION RATE
 NOTE OSAD O&S AVAILABLE DEFICIT
 NOTE OSDRAD O&S DOLLARS REALLOCATION DECISION
 R OSDOR.KL(1)=OSDA.K(1)*APRF.K*APRFA.K*OSDSWI.K(1) FN- 89
 NOTE OSDOR O&S DOLLARS OBLIGATED RATE
 NOTE OSDA O&S DOLLARS APPROPRIATED
 NOTE APRF APPROPRIATION FRACTION
 NOTE APRFA APPROPRIATION FRACTION ADJUSTOR
 NOTE OSDSWI O&S DOLLARS SWITCH
 A APRFA.K=TABHL(APRFAT,(OSA.K(1)/OSDA.K(1)+1/MAIMPF),0,5,1) FN- 90
 T APRAT=1.3/1.3/1.22/1.1/1.03/1.0 FN- 91
 NOTE APRFA APPROPRIATION FRACTION ADJUSTOR
 NOTE OSA O&S AVAILABLE
 A OSDSWI.K(PROJ)=SWITCH(0,1,OSDA.K(PROJ)) FN- 92
 NOTE OSDWSI O&S DOLLAR SWITCH
 NOTE OSDA O&S DOLLARS APPROPRIATED

NOTE WEAPON SYSTEM DEVELOPMENT SECTOR
 NOTE
 NOTE
 NOTE ACTUAL PROGRESS SECTION
 NOTE
 NOTE
 L $AP1.K = AP1.J + DT * (APR1.JK - APTR1.JK)$ RD- 1
 N $AP1 = AP1C$ RD- 2
 C $AP1C = 0$ RD- 3
 NOTE AP1 ACTUAL PROGRESS
 NOTE APR1 ACTUAL PROGRESS RATE (PROGRESS/TIME)
 NOTE APTR1 ACTUAL PROGRESS TRANSFER RATE (PROGRESS/TIME)
 R $APR1.KL = TE1.K * PGM1.K * CAPRS1.K$ RD- 4
 N $APR1 = 0$ RD- 5
 N $TE1 = .5$ RD- 6
 A $TE1.K = 1 / TCF.K * ME1$ RD- 7
 C $ME1 = 1$ RD- 8
 NOTE APR1 ACTUAL PROGRESS RATE
 NOTE TE1.K TECHNICAL EFFECTIVENESS
 NOTE PGM1 PROGRAM
 NOTE CAPRS1 CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED) (FRACTION)
 NOTE ME1 MANAGEMENT EFFECTIVENESS
 A $PGM1.K = TABHL(PGM1T, SCHED1.K, 0, 1, .083) * WSD1.K * DCP1.K * 12 /$ RD- 9
 X $(TTMS1.K + TSMS0.K)$
 T $PGM1T = 0 / 3 / 6 / 7.5 / 9 / 9.67 / 10.33 / 11 / 11 / 11 / 11 / 0$ RD- 10
 NOTE- PGM1 PROGRAM
 NOTE SCHED SCHEDULE
 NOTE TSMS0 TIME SINCE MILESTONE 0
 NOTE TTMS1 TIME TIL MILESTONE 1
 NOTE WSD1 WEAPONS SYSTEM DEVELOPMENT PHASE 1
 NOTE DCP1 DECISION COORD PAPER 1
 A $SCHED1.K = TSMS0.K / (TSMS0.K + TTMS1.K)$ RD- 11
 A $CAPRS1.K = SMOOTH(CAPR1.K, CAPRD)$ RD- 12
 C $CAPRD = 1$ RD- 13
 A $CAPR1.K = FLF1.K * DCAPR1.K$ RD- 14
 NOTE CAPRS1 CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED)
 NOTE CAPR1 CHANGE IN ACTUAL PROGRESS RATE
 NOTE CAPRD CHANGE IN ACTUAL RATE DELAY
 NOTE FLF1 FUNDS LIMIT FACTOR
 NOTE DCAPR1 DESIRED CHANGE IN ACTUAL PROGRESS RATE
 A $DCAPR1.K = APR1.JK - DPR1.K$ RD- 15
 NOTE DCAPR1 DESIRED CHANGE IN ACTUAL PROGRESS RATE
 NOTE APR1 ACTUAL PROGRESS RATE
 NOTE DPR1 DESIRED PROGRESS RATE
 NOTE
 A $PAP1.K = SMOOTH(AP1.K, APD)$ RD- 16
 C $APD = 1$ RD- 17
 NOTE PAP1 PERCEIVED ACTUAL PROGRESS
 NOTE AP1 ACTUAL PROGRESS

NOTE	APD	ACTUAL PROGRESS DELAY	
A	RAP1.K=TPG-PAP1.K		RD- 18
C	TPG=100		RD- 19
NOTE	RAP1	REMAINING ACTUAL PROGRESS	
NOTE	TPG	TOTAL PROGRESS GOAL	
NOTE	PAP1	PERCEIVED ACTUAL PROGRESS	
FOR I=1,10			
A	PRR1.K(I)=RAP1.K/RTTMS1.K(I)		RD- 20
NOTE	PRR1	PROGRESS RATE REQUIRED	
NOTE	RAP1	REMAINING ACTUAL PROGRESS	
NOTE	RTTMS1	REVISED TIME TIL MILESTONE 1	
A	RTTMS1.K(I)=TTMS1.K+TL1.K(I)		RD- 21
T	TL1(I)=1/2/3/4/5/6/7/8/9/10		RD- 22
NOTE	RTTMS1	REVISED TIME TIL MILESTONE 1	
NOTE	TTMS1	TIME TIL MILESTONE 1	
NOTE	TL1	TIME LATE	
A	CF1.K(I)=TABHL(CFT,PRR1.K(I),.6,1.6,.1)		RD- 23
T	CFT=1.15/1.06/1.02/1.01/1.0/1.1/1.25/1.38/1.62/2.0/3.0		RD- 24
NOTE	CF1	COST FACTOR	
NOTE	PRR1	PROGRESS RATE REQUIRED	
A	CP1.K(I)=CF1.K(I)*RTTMS1.K(I)		RD- 25
NOTE	CP1	COST PENALTY	
NOTE	CF1	COST FACTOR	
NOTE	RTTMS1	REVISED TIME TIL MILESTONE 1	
A	SF1.K(I)=TABHL(SFT,TL1.K(I),1,10,1)		RD- 26
T	SFT=1.0/1.01/1.1/1.25/1.4/1.58/1.75/1.87/1.95/2.0/2.0		RD- 27
NOTE	SF1	SCHEDULE FACTOR	
NOTE	TL1	TIME LATE	
A	SP1.K(I)=SF1.K(I)*TL1.K(I)		RD- 28
NOTE	SP1	SCHEDULE PENALTY	
NOTE	SF1	SCHEDULE FACTOR	
NOTE	TL1	TIME LATE	
A	TC1.K(I)=(CWF*CP1.K(I))+(SWF*SP1.K(I))		RD- 29
C	CWF=.5		RD- 30
C	SWF=.5		RD- 31
NOTE	TC1	TOTAL COST	
NOTE	CWF	COST WEIGHT FACTOR	
NOTE	CP1	COST PENALTY	
NOTE	SWF	SCHEDULE WEIGHT FACTOR	
NOTE	SP1	SCHEDULE PENALTY	
FNCTN	DPR1(6,2,001111)		RD- 32
NOTE			
A	DATA.K=DPR1(DTL1.K,DCF.K,TC1.K,PRR1.K,CF1.K,TL1.K)		RD- 33
NOTE	PLANNED PROGRESS		
NOTE			
L	PP1.K=PP1.J+DT*(PPCM1.JK-PPTX1.JK)		RD- 34
N	PP1=PP1C		RD- 35
C	PP1C=0		RD- 36
NOTE	PP1	PLANNED PROGRESS	

NOTE PPGM1 PLANNED PROGRAM RATE
 NOTE PPTX1 PLANNED PROGRESS TRANSFER RATE
 R $PPGM1.KL=TABLE(PCMT,PSCHD1.K,0,1,.083)*WSD1.K*DCP1.K*$ RD- 37
 X $12/TICP.K$
 A $PSCHD1.K=TSMS0.K/TICP.K$ RD- 38
 NOTE PPGM1 PLANNED PROGRAM RATE
 NOTE WSD WEAPON SYSTEM DEVELOPMENT DECISION
 NOTE DCP DECISION COORD POINT
 NOTE TICP TIME IN CONCEPTUAL PHASE
 NOTE PSCHD1 PLANNED SCHEDULE
 NOTE TSMS TIME SINCE MILESTONE
 NOTE
 NOTE
 NOTE PRESSURE FOR SCHEDULE EXTENSION
 NOTE
 A $PSE1.K=TABLE(PSE1,ELF1.K,0,1,.2)$ RD- 39
 T $PSET=0.0/.15/.35/.50/.88/1.0$ RD- 40
 NOTE PSE1 PRESSURE FOR SCHEDULE EXTENSION
 NOTE ELF1 ESTIMATED LATE FACTOR
 A $ELF1.K=DTL1.K/TTMS1.K$ RD- 41
 NOTE ELF ESTIMATED LATE FACTOR
 NOTE DTL1 DESIRED TIME LATE
 NOTE TTMS1 TIME TIL MILESTONE 1
 A $SEA1.K=(PSE1.K*CRPA1.K/USURGF.K)$ RD- 42
 NOTE SEA1 SCHEDULE EXTENSION ADJUSTOR
 NOTE CRPA1 COST RATIO: PLANNED TO ACTUAL
 A $CRPA1.K=PC1.K/CR1.K$ RD- 43
 NOTE CRPA1 COST RATIO: PLANNED TO ACTUAL
 NOTE PC1 PLANNED COST
 NOTE CR1 COST REPORTED
 A $SCD1.K=CLIP(SEA1.K,0,SEA1.K,.5)$ RD- 44
 NOTE SCD1 SCHEDULE EXTENSION DECISION
 NOTE SEA1 SCHEDULE EXTENSION ADJUSTOR
 A $SCDM1.K=CLIP(1,SCD1.K,SCD1.K,1)$ RD- 45
 NOTE SCDM1 SCHEDULE MULTIPLIER
 A $CMS1.K=SCDM.K*DTL1.K$ RD- 46
 NOTE CMS1 CHANGE IN MILESTONE 1
 NOTE SCD1 SCHEDULE EXTENSION DECISION
 NOTE DTL1 DESIRED TIME LATE
 NOTE
 NOTE COST REPORTING
 NOTE
 L $CR1.K=CR1.J+DT*(CRR1.JK-CRTR1.JK)$ RD- 47
 N $CR1=CR10$ RD- 48
 C $CR10=$ RD- 49
 NOTE CR1 COST REPORTED
 NOTE CRR1 COST REPORTING RATE
 NOTE CRTR1 COST REPORTING TRANSFER RATE
 R $CRR1.KL=CE1*DCFS1.K*PPGM1.K/PTCR$ RD- 50

C	CE1=1		RD- 51
NOTE	CRR1	COST REPORTED RATE	
NOTE	CE1	COST ESTIMATING ERROR	
NOTE	DCFS1	DESIRED COST FACTOR (SMOOTHED)	
A	DCFS1.K=SMOOTH(DCF1.K,DCFD)		RD- 52
C	DCFD=1		RD- 53
NOTE	DCFS1	DESIRED COST FACTOR (SMOOTHED)	
NOTE	DCF1	DESIRED COST FACTOR	
NOTE	DCFD	DESIRED COST FACTOR DELAY	
NOTE			
NOTE	PLANNED COSTS		
NOTE			
L	PC1.K=PC1.J+DT*(PCR1.JK-PCTR1.JK)		RD- 54
N	PC1=PC1C		RD- 55
C	PC1C=0		RD- 56
NOTE	PC1	PLANNED COSTS	
NOTE	PCR1	PLANNED COST RATE	
NOTE	PCTR1	PLANNED COST TRANSFER RATE	
R	PCR1.KL=PPGM1.JK/PTCR+CPC1.K		RD- 57
C	PTCR=100		RD- 58
NOTE	PCR1	PLANNED COST RATE	
NOTE	PPGM1	PROGRAM	
NOTE	PTCR	PROGRESS TO COST RATIO	
A	TPC1.K=TPG/PTCR+CPC1.K		RD- 59
NOTE	TPC1	TOTAL PLANNED COST	
NOTE	TPG1	TOTAL PROGRESS GOAL	
NOTE	PTCR	PROGRESS TO COST RATIO	
NOTE	CPC1	CHANGE IN PLANNED COST	
NOTE			
NOTE	PRODUCT VALUE		
NOTE			
L	PV1.K=PV1.J+DT*(PVR1.JK-PVTR1.JK)		RD- 60
N	PV1=PV1C		RD- 61
C	PV1C=0		RD- 62
NOTE	PV1	PRODUCT VALUE	
NOTE	PVR1	PRODUCT VALUE RATE	
NOTE	PVTR1	PRODUCT VALUE TRANSFER RATE	
R	PVR1.KL=PPVS1.K*PVA1.K		RD- 63
NOTE	PVR1	PRODUCT VALUE RATE	
NOTE	PPVS1	PLANNED PRODUCT VALUE (SMOOTHED)	
NOTE	PVA1	PRODUCT VALUE ADJUSTOR	
A	PPVS1.K=SMOOTH(PP1.K,PPD)		RD- 64
C	PPD=1		RD- 65
NOTE	PPVS1	PLANNED PRODUCT VALUE (SMOOTHED)	
NOTE	PP1	PLANNED PROGRESS	
NOTE	PPD	PLANNED PROGRESS DELAY	
A	PVA1.K=PRAP1.K*CRPA1.K		RD- 66
NOTE	PVA1	PRODUCT VALUE ADJUSTOR	
NOTE	PRAP1	PROGRESS RATIO, ACTUAL TO PLANNED	

NOTE CRPA1 COST RATIO, PLANNED TO ACTUAL
 A PRAP1.K=PAP1.K/PP1.K RD- 67
 NOTE PRAP1 PROGRESS RATIO, ACTUAL TO PLANNED
 NOTE PAP1 PERCEIVED ACTUAL PROGRESS
 NOTE PP1 PLANNED PROGRESS
 A CRPA1.K=PC1.K/CR1.K RD- 68
 NOTE CRPA1 COST RATIO, PLANNED TO ACTUAL
 NOTE PC1 PLANNED COST
 NOTE CR1 COST REPORTED
 NOTE
 NOTE FUNDS LIMIT AND PRESSURE FOR ADDITIONAL FUNDS
 NOTE
 A FLF1.K=TABHL(FLFT,3*TWC1.K,0,10,1) RD- 69
 T FLFT=0/0/.11/.22/.33/.45/.55/.66/.77/.88/1.0 RD- 70
 NOTE FLF1 FUNDS LIMIT FACTOR
 NOTE TWC1 TIME WEIGHTED COST
 A TWC1.K=TTMS1.K*CRPA1.K RD- 71
 NOTE TWC1 TIME WEIGHTED COST
 NOTE TTMS1 TIME TIL MILESTONE 1
 NOTE CRPA1 COST RATIO, PLANNED TO ACTUAL
 A PIF1.K=TABHL(PIFT,FLF1.K,0,1.4,.2) RD- 72
 T PIFT=1/.72/.57/.45/.38/.32/.28/.26/.25 RD- 73
 NOTE PIF1 PRESSURE FOR INCREASED FUNDS
 NOTE FLF1 FUNDS LIMIT FACTOR
 A ITAF1.K=FA1.K*PIF1.K*PRAP1.K*USURGF.K*MAIMPF) RD- 74
 NOTE ITAF1 INCLINATION TO APPROVE FUNDS
 NOTE FA1 FUNDS AVAILABILITY
 NOTE PIF1 PRESSURE FOR INCREASED FUNDS
 NOTE PRAP1 PROGRESS RATIO, ACTUAL TO PLANNED
 NOTE MAIMPF MISSION AREA IMPORTANCE FACTOR
 A FID1.K=TABHL(FIDT,ITAF1.K,.8,2.0,.2) RD- 75
 T FIDT=0/.375/.62/.75/.86/.92/.96/.97 RD- 76
 NOTE FID1 FUNDS INCREASE DECISION
 NOTE ITAF1 INCLINATION TO APPROVE FUNDS
 A CPC1.K=FID1.K+ECC1.K RD- 77
 NOTE CPC1 CHANGE IN PLANNED COST
 NOTE FID1 FUNDS INCREASE DECISION
 NOTE ECC1 ESTIMATED CHANGE IN COST
 A ECC1.K=CLIP(ICR1.K,0,ICR1.K,0)*(TSMS0.K+TTMS1.K)/PTCR RD- 78
 A ICR1.K=1-1/CRPA1.K RD- 79
 NOTE ECC1 ESTIMATED CHANGE IN COST
 NOTE CRPA1 COST RATIO, PLANNED TO ACTUAL
 NOTE TSMS0 TIME SINCE MILESTONE 0
 NOTE TTMS1 TIME TIL MILESTONE 1
 NOTE PTCR PROGRESS TO COST RATIO
 NOTE ICR INCREASE IN COST RATE
 A FA1.K=TABHL(FAT,FAF1.K,0,.4,.05) RD- 80
 T FAT=0/.55/.375/.25/.1/.05/.02/.001/.0 RD- 81
 NOTE FA1 FUNDS AVAILABILITY

NOTE FAF1 FUNDS AVAILABILITY FACTOR
 A $FAF1.K = ECC1.K / RDA.K(2)$ RD- 82
 NOTE FAF FUNDS AVAILABILITY FACTOR
 NOTE ECC1 ESTIMATED CHANGE IN COST
 NOTE RDA(2) RESEARCH DOLLARS APPROPRIATED
 NOTE WEAPON SYSTEM DEVELOPMENT-VALIDATION
 NOTE
 NOTE ACTUAL PROGRESS SECTION
 NOTE
 L $AP2.K = AP2.J + DT * (APR2.JK - APTR2.JK)$ RD- 83
 N $AP2 = AP2C$ RD- 84
 C $AP2C = 0$ RD- 85
 NOTE AP2 ACTUAL PROGRESS
 NOTE APR2 ACTUAL PROGRESS RATE (PROGRESS/TIME)
 NOTE APTR2 ACTUAL PROGRESS TRANSFER RATE (PROGRESS/TIME)
 R $APR2.KL = TE2.K * PGM2.K + CAPRS2.K$ RD- 86
 A $TE2.K = 1 / TCF.K * ME2 + PAST1.K / PSTPP1.K$ RD- 87
 C $ME2 = 1$ RD- 88
 NOTE APR2 ACTUAL PROGRESS RATE
 NOTE TE2.K TECHNICAL EFFECTIVENESS
 NOTE PGM2 PROGRAM
 NOTE CAPRS2 CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED)
 NOTE ME2 MANAGEMENT EFFECTIVENESS
 A $PGM2.K = TABLE(PGM1T, SCHED2.K, 0, 1, .0833) * WSD2.K + DCP2.K + 12 /$ RD- 89
 X $(TTMS2.K + TSMS1.K)$
 NOTE- PGM2 PROGRAM
 NOTE TTMS2 TIME TIL MILESTONE 2
 NOTE WSD2 WEAPONS SYSTEM DEVELOPMENT PHASE 2
 NOTE DCP2 DECISION COORD PAPER 2
 A $SCHED2.K = TSMS1.K / (TSMS1.K + TTMS2.K)$ RD- 90
 A $CAPRS2.K = SMOOTH(CAPR2.K, CAPRD)$ RD- 91
 A $CAPR2.K = FLF2.K * DCAPR2.K$ RD- 92
 NOTE CAPRS2 CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED)
 NOTE CAPR2 CHANGE IN ACTUAL PROGRESS RATE
 NOTE CAPRD2 CHANGE IN ACTUAL RATE DELAY
 NOTE FLF2 FUNDS LIMIT FACTOR
 NOTE DCAPR2 DESIRED CHANGE IN ACTUAL PROGRESS RATE
 A $DCAPR2.K = APR2.JK - DPR2.K$ RD- 93
 NOTE DCAPR2 DESIRED CHANGE IN ACTUAL PROGRESS RATE
 NOTE APR2 ACTUAL PROGRESS RATE
 NOTE DPR2 DESIRED PROGRESS RATE
 NOTE
 A $PAP2.K = SMOOTH(AP2.K, APD)$ RD- 94
 NOTE PAP2 PERCEIVED ACTUAL PROGRESS
 NOTE AP2 ACTUAL PROGRESS
 NOTE APD ACTUAL PROGRESS DELAY
 A $RAP2.K = TPG - PAP2.K$ RD- 95
 NOTE RAP2 REMAINING ACTUAL PROGRESS
 NOTE TPG TOTAL PROGRESS GOAL
 NOTE PAP2 PERCEIVED ACTUAL PROGRESS

A	PRR2.K(I)=RAP2.K/RTTMS2.K(I)	RD- 96
NOTE	PRR2	PROGRESS RATE REQUIRED
NOTE	RAP2	REMAINING ACTUAL PROGRESS
NOTE	RTTMS2	REVISED TIME TIL MILESTONE 2
A	RTTMS1.K(I)=TTMS2.K+T(I)	RD- 97
NOTE	RTTMS2	REVISED TIME TIL MILESTONE 2
NOTE	TTMS2	TIME TIL MILESTONE 2
NOTE	T	TIME
A	CF2.K(I)=TABHL(CFT2,PRR2.K(I),.6,.2,.2)	RD- 98
NOTE	CF2	COST FACTOR
NOTE	PRR2	PROGRESS RATE REQUIRED
A	CP2.K(I)=CF2.K(I)*RTTMS2.K(I)	RD- 99
NOTE	CP2	COST PENALTY
NOTE	CF2	COST FACTOR
NOTE	RTTMS2	REVISED TIME TIL MILESTONE 2
A	SF2.K(I)=TABHL(SFT,T(I),1,10,1)	RD- 100
NOTE	SF2	SCHEDULE FACTOR
NOTE	T	TIME
A	SP2.K(I)=SF2.K(I)*T(I)	RD- 101
NOTE	SP2	SCHEDULE PENALTY
NOTE	SF2	SCHEDULE FACTOR
NOTE	T	TIME
A	TC2.K(I)=(CWF*CP2.K(I))+(SWF*SP2.K(I))	RD- 102
C	SWF=.5	RD- 103
NOTE	TC2	TOTAL COST
NOTE	CWF	COST WEIGHT FACTOR
NOTE	CP2	COST PENALTY
NOTE	SWF	SCHEDULE WEIGHT FACTOR
NOTE	SP2	SCHEDULE PENALTY
A	DATA2.K=DPR2(DTL2.K,DCF2.K,TC2.K,PRR2.K,CF2.K,TL1.K)	RD- 104
NOTE		PLANNED PROGRESS
NOTE		
L	PP2.K=PP2.J+DT*(PPGM2.JK-PPTX2.JK)	RD- 105
N	PP2=PP2C	RD- 106
C	PP2C=0	RD- 107
NOTE	PP2	PLANNED PROGRESS
NOTE	PPR2	PLANNED PROGRESS RATE
NOTE	PPTX2	PLANNED PROGRESS TRANSFER RATE
R	PPGM2.KL=TABLE(PGM1T,PSCHD2.K,0,1,.003)*WSD2.K+DCP2.K	RD- 108
X	*12/TIVP.K	
A	PSCHD2.K=TSMS1.K/TIVP.K	RD- 109
NOTE		
NOTE		PRESSURE FOR SCHEDULE EXTENSION
NOTE		
A	PSE2.K=TABHL(PSET,ELF2.K,0,1,.2)	RD- 110
NOTE	PSE2	PRESSURE FOR SCHEDULE EXTENSION
NOTE	ELF2	ESTIMATED LATE FACTOR
A	ELF2.K=DTL2.K/TTMS2.K	RD- 111
NOTE	ELF	ESTIMATED LATE FACTOR

NOTE	DTL2	DESIRED TIME LATE	
NOTE	TTMS2	TIME TIL MILESTONE 2	
A	SEA2.K=PSE2.K*USURGF.K*CRPA2.K		RD- 112
NOTE	SEA2	SCHEDULE EXTENSION ADJUSTOR	
NOTE	CRPA2	COST RATIO, PLANNED TO ACTUAL	
A	CRPA2.K=PC2.K/CR2.K		RD- 113
NOTE	CRPA2	COST RATIO, PLANNED TO ACTUAL	
NOTE	PC2	PLANNED COST	
NOTE	CR2	COST REPORTED	
A	SCD2.K=CLIP(2,0,SEA2.K,6)		RD- 114
NOTE	SCD2	SCHEDULE EXTENSION DECISION	
NOTE	SEA2	SCHEDULE EXTENSION ADJUSTOR	
A	CMS2.K=SCDM2.K*DTL2.K		RD- 115
A	SCHM2.K=CLIP(1,SCH2.K,SCH2.K,1)		RD- 116
NOTE	CMS2	CHANGE IN MILESTONE 2	
NOTE	SCD2	SCHEDULE EXTENSION DECISION	
NOTE	DTL2	DESIRED TIME LATE	
NOTE			
NOTE		COST REPORTING	
NOTE			
L	CR2.K=CR2.J+DT*(CRR2.JK-CRTR2.JK)		RD- 117
N	CR2=CR2C		RD- 118
C	CR2C=0		RD- 119
NOTE	CR2	COST REPORTED	
NOTE	CRR2	COST REPORTING RATE	
NOTE	CRTR2	COST REPORTING TRANSFER RATE	
R	CRR2.KL=CE2*DCFS2.K*PGM2.K/PTCR		RD- 120
C	CE2=2		RD- 121
NOTE	CRR2	COST REPORTED RATE	
NOTE	CE2	COST ESTIMATING ERROR	
NOTE	DCFS2	DESIRED COST FACTOR (SMOOTHED)	
NOTE	PGM2	PROGRAM	
A	DCFS2.K=SMOOTH(DCF2.K,DCFD)		RD- 122
C	DCFD=1		RD- 123
NOTE	DCFS2	DESIRED COST FACTOR (SMOOTHED)	
NOTE	DCF2	DESIRED COST FACTOR	
NOTE	DCFD	DESIRED COST FACTOR DELAY	
NOTE			
NOTE		PLANNED COSTS	
NOTE			
L	PC2.K=PC2.J+DT*(PCR2.JK-PCTR2.JK)		RD- 124
N	PC2=PC2C		RD- 125
C	PC2C=0		RD- 126
NOTE	PC2	PLANNED COSTS	
NOTE	PCR2	PLANNED COST RATE	
NOTE	PCTR2	PLANNED COST TRANSFER RATE	
R	PCR2.KL=PPGM2.JK/PTCR+CPC2.K		RD- 127
NOTE	PCR2	PLANNED COST RATE	
NOTE	PGM2	PROGRAM	

AD-A072 618 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/0 5/1
A DYNAMIC POLICY MODEL OF THE DEPARTMENT OF DEFENSE SYSTEMS ACQ--ETC(U)
JUN 79 S A KAFFENBERGER, D P MARTIN

AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/0 5/1
A DYNAMIC POLICY MODEL OF THE DEPARTMENT OF DEFENSE SYSTEMS ACQ--ETC(U)
JUN 79 S A KAFFENBERGER, D P MARTIN

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NOTE	PTCR	PROGRESS TO COST RATIO	
A	TPC2.K=TPG/PTCR+CPC2.K		RD- 128
NOTE	TPC2	TOTAL PLANNED COST	
NOTE	TPG2	TOTAL PROGRESS GOAL	
NOTE	PTCR	PROGRESS TO COST RATIO	
NOTE	CPC2	CHANGE IN PLANNED COST	
NOTE			
NOTE	PRODUCT VALUE		
NOTE			
L	PV2.K=PV2.J+DT*(PVR2.JK-PVTR2.JK)		RD- 129
N	PV2=PV2C		RD- 130
C	PV2C=0		RD- 131
NOTE	PV2	PRODUCT VALUE	
NOTE	PVR2	PRODUCT VALUE RATE	
NOTE	PVTR2	PRODUCT VALUE TRANSFER RATE	
R	PVR2.KL=PPVS2.K+PVA2.K		RD- 132
NOTE	PVR2	PRODUCT VALUE RATE	
NOTE	PPVS2	PLANNED PRODUCT VALUE (SMOOTHED)	
NOTE	PVA2	PRODUCT VALUE ADJUSTOR	
A	PPVS2.K=SMOOTH(PP2.K,PPD)		RD- 133
NOTE	PPVS2	PLANNED PRODUCT VALUE (SMOOTHED)	
NOTE	PP2	PLANNED PROGRESS	
NOTE	PP2D	PLANNED PROGRESS DELAY	
A	PVA2.K=PRAP2.K+CRPA2.K		RD- 134
NOTE	PVA2	PRODUCT VALUE ADJUSTOR	
NOTE	PRAP2	PROGRESS RATIO, ACTUAL TO PLANNED	
NOTE	CRPA2	COST RATIO, PLANNED TO ACTUAL	
A	PRAP2.K=PAP2.K/PP2.K		RD- 135
NOTE	PRAP2	PROGRESS RATIO, ACTUAL TO PLANNED	
NOTE	PAP2	PERCEIVED ACTUAL PROGRESS	
NOTE	PP2	PLANNED PROGRESS	
A	CRPA2.K=PC2.K/CR2.K		RD- 136
NOTE	CRPA2	COST RATIO, PLANNED TO ACTUAL	
NOTE	PC2	PLANNED COST	
NOTE	CR2	COST REPORTED	
NOTE			
NOTE	FUNDS LIMIT AND PRESSURE FOR ADDITIONAL FUNDS		
NOTE			
A	FLF2.K=TABHL(FLFT,2*TWC2.K,0,10,1)		RD- 137
NOTE	FLF2	FUNDS LIMIT FACTOR	
NOTE	TWC2	TIME WEIGHTED COST	
A	TWC2.K=TTMS2.K+CRPA2.K		RD- 138
NOTE	TWC2	TIME WEIGHTED COST	
NOTE	TTMS2	TIME TIL MILESTONE 2	
NOTE	CRPA2	COST RATIO, PLANNED TO ACTUAL	
A	PIF2.K=TABHL(PIFT,FLF2.K,0,1.4,2)		RD- 139
NOTE	PIF2	PRESSURE FOR INCREASED FUNDS	
NOTE	FLF2	FUNDS LIMIT FACTOR	
A	ITAF2.K=FA2.K+PIF2.K+PRAP2.K+USURGF.K+MAIMPF)		RD- 140

NOTE ITAF2 INCLINATION TO APPROVE FUNDS
 NOTE FA2 FUNDS AVAILABILITY
 NOTE PIF2 PRESSURE FOR INCREASED FUNDS
 NOTE PRAP2 PROGRESS RATIO, ACTUAL TO PLANNED
 NOTE MAIMPF MISSION AREA IMPORTANCE FACTOR
 A $FID2.K = TABHL(FIDT, ITAF2.K, .8, 2.0, .2)$ RD- 141
 NOTE FID2 FUNDS INCREASE DECISION
 NOTE ITAF2 INCLINATION TO APPROVE FUNDS
 A $CPC2.K = FID2.K * ECC2.K$ RD- 142
 NOTE CPC2 CHANGE IN PLANNED COST
 NOTE FID2 FUNDS INCREASE DECISION
 NOTE ECC2 ESTIMATED CHANGE IN COST
 A $ECC2.K = (TSMS\emptyset.K + TTMS2.K) / (PTCR * CRPA2.K)$ RD- 143
 NOTE ECC2 ESTIMATED CHANGE IN COST
 NOTE CRPA2 COST RATIO, PLANNED TO ACTUAL
 NOTE TSMS\emptyset TIME SINCE MILESTONE \emptyset
 NOTE TTMS2 TIME TIL MILESTONE 2
 NOTE PTCR PROGRESS TO COST RATIO
 NOTE
 A $FA2.K = TABHL(FAT, FAF2.K, \emptyset, .4, .05)$ RD- 144
 NOTE FA2 FUNDS AVAILABILITY
 NOTE FAF2 FUNDS AVAILABILITY FACTOR
 A $FAF2.K = ECC2.K / RDA.K(2)$ RD- 145
 NOTE FAF FUNDS AVAILABILITY FACTOR
 NOTE ECC2 ESTIMATED CHANGE IN COST
 NOTE RDA(2) RESEARCH DOLLARS APPROPRIATED
 NOTE
 NOTE WEAPON SYSTEM DEVELOPMENT-FULL SCALE DEVELOPMENT
 NOTE ACTUAL PROGRESS SECTION
 NOTE
 L $AP3.K = AP3.J + DT * (APR3.JK - APTR3.JK)$ RD- 146
 N $AP3 = AP3C$ RD- 147
 C $AP3C = \emptyset$ RD- 148
 NOTE AP3 ACTUAL PROGRESS
 NOTE APR3 ACTUAL PROGRESS RATE (PROGRESS/TIME)
 NOTE APTR3 ACTUAL PROGRESS TRANSFER RATE (PROGRESS/TIME)
 R $APR3.KL = TE3.K + PCM3.K * CAPRS3.K$ RD- 149
 A $TE3.K = 1 / TCF.K * ME3 * PASTP2.K / PSTPP2.K$ RD- 150
 C $ME3 = 1$ RD- 151
 NOTE APR3 ACTUAL PROGRESS RATE
 NOTE TE3.K TECHNICAL EFFECTIVENESS
 NOTE PCM3 PROGRAM
 NOTE CAPRS3 CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED) (FRACTIO
 NOTE ME3 MANAGEMENT EFFECTIVENESS
 A $PCM3.K = TABHL(PCM3T, SCHED3.K, \emptyset, 3, .083) * WSD3.K * DCP3.K * 12 /$ RD- 152
 X $(TTMS3.K + TSMS2.K)$
 NOTE- PCM3 PROGRAM
 NOTE TTMS3 TIME TIL MILESTONE 3
 NOTE WSD3 WEAPONS SYSTEM DEVELOPMENT PHASE 3

NOTE	DCP3	DECISION COORD PAPER 3	
A	SCHED3.K	=TSMS2.K/(TSMS2.K+TTMS3.K)	RD- 153
A	CAPRS3.K	=SMOOTH(CAPR3.K,CAPRD)	RD- 154
A	CAPR3.K	=FLF3.K*DCAPR3.K	RD- 155
NOTE	CAPRS3	CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED)	
NOTE	CAPR3	CHANGE IN ACTUAL PROGRESS RATE	
NOTE	CAPRD	CHANGE IN ACTUAL RATE DELAY	
NOTE	FLF3	FUNDS LIMIT FACTOR	
NOTE	DCAPR3	DESIRED CHANGE IN ACTUAL PROGRESS RATE	
A	DCAPR3.K	=APR3.K-DPR3.K	RD- 156
NOTE	DCAPR3	DESIRED CHANGE IN ACTUAL PROGRESS RATE	
NOTE	APR3	ACTUAL PROGRESS RATE	
NOTE	DPR3	DESIRED PROGRESS RATE	
NOTE			
A	PAP3.K	=SMOOTH(AP3.K,APD3)	RD- 157
C	APD3	=1	RD- 158
NOTE	PAP3	PERCEIVED ACTUAL PROGRESS	
NOTE	AP3	ACTUAL PROGRESS	
NOTE	APD3	ACTUAL PROGRESS DELAY	
A	RAP3.K	=TPG-PAP3.K	RD- 159
NOTE	RAP3	REMAINING ACTUAL PROGRESS	
NOTE	TPG	TOTAL PROGRESS GOAL	
NOTE	PAP3	PERCEIVED ACTUAL PROGRESS	
A	PRR3.K(I)	=RAP3.K/RTTMS3.K(I)	RD- 160
NOTE	PRR3	PROGRESS RATE REQUIRED	
NOTE	RAP3	REMAINING ACTUAL PROGRESS	
NOTE	RTTMS3	REVISED TIME TIL MILESTONE 3	
A	RTTMS1.K(I)	=TTMS3.K(I)+T(I)	RD- 161
NOTE	RTTMS3	REVISED TIME TIL MILESTONE 3	
NOTE	TTMS3	TIME TIL MILESTONE 3	
NOTE	T	TIME	
A	CF3.K(I)	=TABHL(CFT3,PRR3.K(I),.6,2,.2)	RD- 162
NOTE	CF3	COST FACTOR	
NOTE	PRR3	PROGRESS RATE REQUIRED	
A	CP3.K(I)	=CF3.K(I)*RTTMS3.K(I)	RD- 163
NOTE	CP3	COST PENALTY	
NOTE	CF3	COST FACTOR	
NOTE	RTTMS3	REVISED TIME TIL MILESTONE 3	
A	SF3.K(I)	=TABHL(SFT1,T(I),1,10,1)	RD- 164
NOTE	SF3	SCHEDULE FACTOR	
NOTE	T	TIME	
A	SP3.K(I)	=SF3.K(I)*T(I)	RD- 165
NOTE	SP3	SCHEDULE PENALTY	
NOTE	SF3	SCHEDULE FACTOR	
NOTE	T	TIME	
A	TC3.K(I)	=(CWF*CP3.K(I))+(SWF*SP3.K(I))	RD- 166
NOTE	TC3	TOTAL COST	
NOTE	CWF	COST WEIGHT FACTOR	
NOTE	CP3	COST PENALTY	

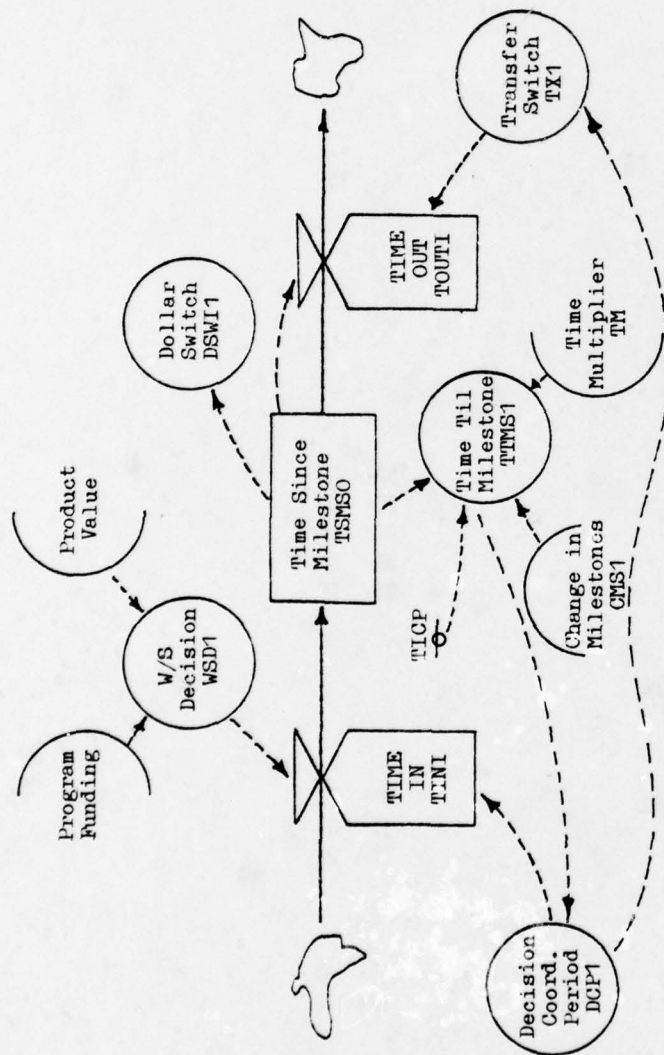
NOTE SWF SCHEDULE WEIGHT FACTOR
 NOTE SP3 SCHEDULE PENALTY
 NOTE
 A DATA3.K=DPR1(DCF3.K,DTL3.K,TC3.K,PRR3.K,CF3.K,T) RD- 167
 NOTE PLANNED PROGRESS
 NOTE
 L PP3.K=PP3.J+DT*(PPCM3.JK-PPTX3.JK) RD- 168
 N PP3=PP3C RD- 169
 C PP3C=0 RD- 170
 NOTE PP3 PLANNED PROGRESS
 NOTE PPCM3 PLANNED PROGRESS RATE
 NOTE PPTX3 PLANNED PROGRESS TRANSFER RATE
 A PSCHD3.K=TSMS3.K/TIFSD.K RD- 171
 R PPCM3.KL=TABLE(PCMIT,PSCHD3.K,0,1,.083)*WSD3.K RD- 172
 X *DCP3.K*12/TIFSD.K
 NOTE
 NOTE PSCHD PLANNED SCHEDULE
 NOTE TSMS3 TIME SINCE MILESTONE 3
 NOTE TIFSD TIME IN FULL-SCALE DEVELOPMENT
 NOTE PPCM3 PLANNED PROGRESS RATE
 NOTE WSD3 WEAPON SYSTEM DECISION
 NOTE DCP3 DECISION COORDINATING POINT
 NOTE
 NOTE
 NOTE PRESSURE FOR SCHEDULE EXTENSION
 NOTE
 A PSE3.K=TABHL(PSE3T,ELF3.K,0,3,.2) RD- 173
 A ELF3.K=DTL3.K/TTMS3.K RD- 174
 NOTE
 NOTE PSE3 PRESSURE FOR SCHEDULE EXTENSION
 NOTE ELF3 ESTIMATED LATE FACTOR
 NOTE DTL3 DESIRED TIME LATE
 NOTE TTMS3 TIME TIL MILESTONE 3
 NOTE
 A SEA3.K=PSE3.K*USURGF.K*CRPA3.K RD- 175
 NOTE
 NOTE SEA3 SCHEDULE EXTENSION ADJUSTOR
 NOTE CRPA3 COST RATIO, PLANNED TO ACTUAL
 NOTE
 A SCD3.K=CLIP(3,0,SEA3.K,.6) RD- 176
 A CMS3.K=SCD3.K*DTL3.K RD- 177
 NOTE
 NOTE SCD3 SCHEDULE EXTENSION DECISION
 NOTE SEA3 SCHEDULE EXTENSION ADJUSTOR
 NOTE CMS3 CHANGE IN MILESTONE 3
 NOTE DTL3 DESIRED TIME LATE
 NOTE
 NOTE COST REPORTING
 NOTE

L	$CR3.K = CR3.J + DT * (CRR3.JK - CRTR3.JK)$	RD- 178
N	$CR3 = CR3C$	RD- 179
C	$CR3C = 0$	RD- 180
R	$CRR3.KL = CE3 * DCFS3.K + PGM3.K / PTCR$	RD- 181
C	$CE3 = 1$	RD- 182
A	$DCFS3.K = SMOOTH(DCF3.K, DCF3D)$	RD- 183
C	$DCF3D = 1$	RD- 184
NOTE		
NOTE	CR3 COST REPORTED	
NOTE	CRR3 COST REPORTING RATE	
NOTE	CRTR3 COST REPORTING TRANSFER RATE	
NOTE	CE3 COST ESTIMATING ERROR	
NOTE	PGM3 PROGRAM	
NOTE	DCFS3 DESIRED COST FACTOR (SMOOTHED)	
NOTE	DCF3 DESIRED COST FACTOR	
NOTE	DCF3D DESIRED COST FACTOR DELAY	
NOTE		
NOTE	PLANNED COSTS	
NOTE		
L	$PC3.K = PC3.J + DT * (PCR3.JK - PTR3.JK)$	RD- 185
N	$PC3 = PC3C$	RD- 186
C	$PC3C = 0$	RD- 187
R	$PCR3.KL = PPGM3.JK / PTCR + CPC3.K$	RD- 188
NOTE		
NOTE	PC3 PLANNED COSTS	
NOTE	PCR3 PLANNED COST RATE	
NOTE	PCTR3 PLANNED COST TRANSFER RATE	
NOTE	PGM3 PROGRAM	
NOTE	PTCR PROGRESS TO COST RATIO	
NOTE		
A	$TPC3.K = TPG / PTCR + CPC3.K$	RD- 189
NOTE		
NOTE	TPC3 TOTAL PLANNED COST	
NOTE	TPG3 TOTAL PROGRESS GOAL	
NOTE	PTCR PROGRESS TO COST RATIO	
NOTE	CPC3 CHANGE IN PLANNED COST	
NOTE		
NOTE	PRODUCT VALUE	
NOTE		
L	$PV3.K = PV3.J + DT * (PVR3.JK - PVTR3.JK)$	RD- 190
N	$PV3 = PV3C$	RD- 191
C	$PV3C = 0$	RD- 192
R	$PVR3.KL = PPVS3.K + PVA3.K$	RD- 193
A	$PPVS3.K = SMOOTH(PP3.K, PPD)$	RD- 194
NOTE		
NOTE	PV3 PRODUCT VALUE	
NOTE	PVR3 PRODUCT VALUE RATE	
NOTE	PVTR3 PRODUCT VALUE TRANSFER RATE	
NOTE	PPVS3 PLANNED PRODUCT VALUE (SMOOTHED)	

NOTE PVA3 PRODUCT VALUE ADJUSTOR
 NOTE PP3 PLANNED PROGRESS
 NOTE PPD PLANNED PROGRESS DELAY
 NOTE
 A $PVA3.K = PRAP3.K * CRPA3.K$ RD- 195
 NOTE
 NOTE PVA3 PRODUCT VALUE ADJUSTOR
 NOTE PRAP3 PROGRESS RATIO, ACTUAL TO PLANNED
 NOTE CRPA3 COST RATIO, PLANNED TO ACTUAL
 NOTE
 A $PRAP3.K = PAP3.K / PP3.K$ RD- 196
 NOTE
 NOTE PRAP3 PROGRESS RATIO, ACTUAL TO PLANNED
 NOTE PAP3 PERCEIVED ACTUAL PROGRESS
 NOTE PP3 PLANNED PROGRESS
 NOTE
 A $CRPA3.K = PC3.K / CR3.K$ RD- 197
 NOTE
 NOTE CRPA3 COST RATIO, PLANNED TO ACTUAL
 NOTE PC3 PLANNED COST
 NOTE CR3 COST REPORTED
 NOTE
 NOTE
 NOTE FUNDS LIMIT AND PRESSURE FOR ADDITIONAL FUNDS
 NOTE
 A $FLF3.K = TABHL(FLFT, TWC3.K, 0, 10, 1)$ RD- 198
 NOTE
 NOTE FLF3 FUNDS LIMIT FACTOR
 NOTE TWC3 TIME WEIGHTED COST
 NOTE
 A $TWC3.K = TTMS3.K * CRPA3.K$ RD- 199
 NOTE
 NOTE TWC3 TIME WEIGHTED COST
 NOTE TTMS3 TIME TIL MILESTONE 3
 NOTE CRPA3 COST RATIO, PLANNED TO ACTUAL
 NOTE
 A $PIF3.K = TABHL(PIFT, FLF3.K, 0, 1.4, .2)$ RD- 200
 NOTE
 NOTE PIF3 PRESSURE FOR INCREASED FUNDS
 NOTE FLF3 FUNDS LIMIT FACTOR
 NOTE
 A $ITAF3.K = FAI.K * PIF3.K * PRAP3.K * USURGF.K * MAINPF$ RD- 201
 NOTE
 NOTE ITAF3 INCLINATION TO APPROVE FUNDS
 NOTE FA3 FUNDS AVAILABILITY
 NOTE PIF3 PRESSURE FOR INCREASED FUNDS
 NOTE PRAP3 PROGRESS RATIO, ACTUAL TO PLANNED
 NOTE MAINPF MISSION AREA IMPORTANCE FACTOR
 NOTE

A FID3.K=TABHL(FIDT,ITAF3.K,.8,2.,.2) RD- 202
 NOTE
 NOTE FID3 FUNDS INCREASE DECISION
 NOTE ITAF3 INCLINATION TO APPROVE FUNDS
 NOTE
 A CPC3.K=FID3.K+ECC3.K RD- 203
 NOTE
 NOTE CPC3 CHANGE IN PLANNED COST
 NOTE FID3 FUNDS INCREASE DECISION
 NOTE ECC3 ESTIMATED CHANGE IN COST
 NOTE
 A ECC3.KL=(TSMS0.K+TTMS3.K)/PTCR*CLIP(ICR3.K,0,ICR3.K,0) RD- 204
 NOTE
 NOTE ECC3 ESTIMATED CHANGE IN COST
 NOTE CRPA3 COST RATIO, PLANNED TO ACTUAL
 NOTE TSMS0 TIME SINCE MILESTONE 0
 NOTE TTMS3 TIME TIL MILESTONE 3
 NOTE PTCR PROGRESS TO COST RATIO
 NOTE
 A FA3.K=TABHL(FAT,FAF3.K,0,.4,.05) RD- 205
 NOTE
 NOTE FA3 FUNDS AVAILABILITY
 NOTE FAF3 FUNDS AVAILABILITY FACTOR
 NOTE
 A FAF3.K=ECC3.K/RDA.K(2) RD- 206
 NOTE
 NOTE FAF FUNDS AVAILABILITY FACTOR
 NOTE ECC3 ESTIMATED CHANGE IN COST
 NOTE RDA(2) RESEARCH DOLLARS APPROPRIATED
 NOTE

NOTE WEAPON SYSTEM DEVELOPMENT SECTOR
NOTE
NOTE
A WSD1.K=SWITCH(1,0,RQWWS.K) DT- 1
A WSD2.K=CLIP(1,0,PPV1.K,.8)*RPF.K DT- 2
A WSD3.K=CLIP(1,0,PPV2.K,.8)*RPF.K DT- 3
A WSD4.K=CLIP(1,0,PPV3.K,.8)*IPF.K DT- 4
NOTE
NOTE WSD AUTHORIZES THE VARIOUS PHASES OF WEAPONS DEVELOPMENT
NOTE THE SWITCH IS TURNED ON IF THE PRODUCT VALUE WEIGHTED BY
NOTE URGENCY IS HIGH ENOUGH TO WARRANT CONTINUED DEVELOPMENT.
NOTE THE SWITCH STAYS ON DURING THE ENTIRE PHASE, BUT IS
NOTE TURNED OFF AT THE CANCELLATION OR TRANSFER OF DEVELOPMENT.
NOTE RPF RESEARCH PROGRAM FUNDING
NOTE IPF INVESTMENT PROGRAM FUNDING
NOTE
A DCP1.K=SWITCH(0,1,TTMS1.K) DT- 5
A DCP2.K=SWITCH(0,1,TTMS2.K) DT- 6
A DCP3.K=SWITCH(0,1,TTMS3.K) DT- 7
A DCP4.K=SWITCH(1,0,TTMCC.K) DT- 8
NOTE
NOTE DCP IS THE POINT IN TIME WHERE THE DSARC DECISIONS ARE MADE
NOTE PROGRAMS CAN EITHER BE CANCELLED OR AUTHORIZED FOR FURTHER
NOTE DEVELOPMENT WHEN THE DSARC DCP ARE REVIEWED
NOTE
A TX1.K=SWITCH(1,0,DCP1.K) DT- 9
A TX2.K=SWITCH(1,0,DCP2.K) DT- 10
A TX3.K=SWITCH(1,0,DCP3.K) DT- 11
A TX4.K=SWITCH(1,0,DCP4.K) DT- 12
NOTE
NOTE TX IS THE TRANSFER SWITCH WHICH IS TURNED ON WHEN THE
NOTE DSARC DCP DECISION IS MADE. IT ALLOWS THE PROGRAM LEVELS
NOTE TO BE EMPTIED.
NOTE
A DSW1.K=CLIP(0,1,TSMS0.K,2) DT- 13
A DSW12.K=CLIP(0,1,TSMS1.K,2) DT- 14
A DSW13.K=CLIP(0,1,TSMS2.K,2) DT- 15
A DSW14.K=CLIP(0,1,TSMS3.K,2) DT- 16
NOTE
NOTE DSWI IS THE DOLLAR SWITCH WHICH TURNS ON THE DAY THAT
NOTE MILESTONE DECISION IS MADE TO RELEASE DOLLARS FOR CONTRACTS
NOTE AND OTHER EXPENDITURES THAT OCCUR AFTER APPROVAL.
NOTE TIME CONTROL
NOTE
L FYTIME.K=FYTIME.J+DT*(FYTIN.JK-FYTOUT.JK) DT- 17
N FYTIME=1 DT- 18
NOTE
NOTE FYTIME FISCAL YEAR TIME CLOCK(GEARED TO MONTHS)
NOTE FYTIN FISCAL TIME IN



NOTE: This flow diagram structure is similar for the three development phases and for weapon system production. The documentation in the Decision and Time Control Section in the computer model explains the use of the variables.

Figure C-5

Decision and Time Control

NOTE FYTOUT FISCAL YEAR TIME OUT
 R FYTIN.KL=1 DT- 19
 NOTE FYTIN FISCAL YEAR TIME IN (MONTHS)
 R FYTOUT.KL=FYTIME.K*FYTX.K DT- 20
 NOTE FYTOUT FISCAL YEAR TIME OUT (MONTHS)
 A FYTX.K=CLIP(1,0,FYTIME.K,12) DT- 21
 NOTE FYTX FISCAL YEAR TRANSFER
 NOTE
 L TSMS0.K=TSMS0.J+DT*(TIN1.JK-TOUT1.JK) DT- 22
 N TSMS0=TSMS0C DT- 23
 C TSMS0C=0 DT- 24
 NOTE
 NOTE TSMS0 TIME SINCE MILESTONE 0
 NOTE TIN1 TIME IN PHASE 1
 NOTE TOUT1 TIME OUT OF PHASE 1
 NOTE
 R TIN1.KL=WSD1.K*DCP1.K DT- 25
 R TOUT1.KL=TSMS0.K*TX1.K DT- 26
 NOTE
 NOTE TIN1 TIME IN PHASE 1
 NOTE WSD1 WEAPON SYSTEM DEVELOPMENT 1
 NOTE DCP1 DECISION COORD POINT 1
 NOTE TOUT1 TIME OUT OF PHASE 1
 NOTE TSMS0 TIME SINCE MILESTONE 0
 NOTE TX1 TRANSFER SWITCH 1
 NOTE
 A TTMS1.K=TICP.K-TSMS0.K+CMS1.K DT- 27
 A TICP.K=TICPC+TM.K DT- 28
 C TICPC=12 DT- 29
 N TTMS1=1 DT- 30
 A TM.K=SMOOTH(1/USURGF.K,12) DT- 31
 NOTE TM TIME MULTIPLIER
 NOTE TTMS1 TIME TIL MILESTONE 1
 NOTE TICP TIME IN CONCEPTUAL PHASE
 NOTE TSMS0 TIME SINCE MILESTONE 0
 NOTE CMS1 CHANGE IN MILESTONE 1
 NOTE
 L TSMS1.K=TSMS1.J+DT*(TIN2.JK-TOUT2.JK) DT- 32
 N TSMS1=TSMS1C DT- 33
 C TSMS1C=0 DT- 34
 NOTE TSMS1 TIME SINCE MILESTONE 1
 NOTE TIN2 TIME IN PHASE 2
 NOTE TOUT2 TIME OUT OF PHASE 2
 R TIN2.KL=WSD2.K*DCP2.K DT- 35
 R TOUT2.KL=TSMS1.K*TX2.K DT- 36
 NOTE
 NOTE TSMS1 TIME SINCE MILESTONE 1
 NOTE TIN2 TIME IN PHASE 2
 NOTE WSD2 WEAPON SYSTEM DEVELOPMENT 2

NOTE DCP2 DECISION COORDINATING POINT 2
 NOTE TOUT2 TIME OUT OF PHASE 2
 NOTE TSMS1 TIME SINCE MILESTONE 1
 NOTE TX2 TRANSFER SWITCH 2
 A $TTMS2.K = TIVP.K - TSMS1.K + CMS2.K$ DT- 37
 N $TTMS2 = 1$ DT- 38
 A $TIVP.K = TIVPC + TM.K$ DT- 39
 C $TIVPC = 24$ DT- 40
 NOTE
 NOTE TTMS2 TIME TIL MILESTONE 2
 NOTE TIVP TIME IN DEVELOPMENT PHASE
 NOTE TSMS1 TIME SINCE MILESTONE 1
 NOTE CMS2 CHANGE IN MILESTONE 2
 NOTE TM TIME MULTIPLIER
 NOTE
 L $TSMS2.K = TSMS2.J + DT * (TIN3.JK - TOUT3.JK)$ DT- 41
 N $TSMS2 = TSMS2C$ DT- 42
 C $TSMS2C = 0$ DT- 43
 NOTE TSMS2 TIME SINCE MILESTONE 2
 NOTE TIN3 TIME IN PHASE 3
 NOTE TOUT3 TIME OUT OF PHASE 3
 R $TIN3.KL = WSD3.K + DCP3.K$ DT- 44
 R $TOUT3.KL = TSMS2.K + TX3.K$ DT- 45
 NOTE TSMS2 TIME SINCE MILESTONE 2
 NOTE TIN3 TIME IN PHASE 3
 NOTE WSD3 WEAPON SYSTEM DEVELOPMENT 3
 NOTE DCP3 DECISION COORDINATING POINT 3
 NOTE TOUT3 TIME OUT OF PHASE 3
 NOTE TX3 TRANSFER SWITCH 3
 NOTE
 A $TTMS3.K = TIFSD.K - TSMS2.K + CMS3.K$ DT- 46
 N $TTMS3 = 0$ DT- 47
 A $TIFSD.K = TIFSDC + TM.K$ DT- 48
 C $TIFSDC = 36$ DT- 49
 NOTE
 NOTE TTMS3 TIME TIL MILESTONE 3
 NOTE TIFSD TIME IN FULL SCALE DEVELOPMENT
 NOTE TSMS2 TIME SINCE MILESTONE 2
 NOTE CMS3 CHANGE IN MILESTONE 3
 NOTE TM TIME MULTIPLIER
 NOTE
 L $TSMS3.K = TSMS3.J + DT * (TIN4.JK - TOUT4.JK)$ DT- 50
 N $TSMS3 = TSMS3C$ DT- 51
 C $TSMS3C = 0$ DT- 52
 R $TIN4.KL = WSD4.K + DCP4.K$ DT- 53
 R $TOUT4.KL = TSMS3.K + TX4.K$ DT- 54
 NOTE
 NOTE TSMS3 TIME SINCE MILESTONE 3
 NOTE TIN4 TIME IN PRODUCTION

NOTE WSD WEAPON SYSTEM PRODUCTION DECISION
 NOTE DCP DECISION TO CONTINUE PRODUCTION
 NOTE TOUT3 TIME PRODUCTION COMPLETE
 NOTE TSMS3 TIME SINCE MILESTONE 3
 NOTE TX4 TRANSFER RATE (AT PRODUCTION COMPLETION)
 A $TTPCC.K = TIP.K - TSMS3.K + CMS4.K$ DT- 55
 NOTE TTPCC TIME TIL PRODUCTION CONTRACT COMPLETE
 NOTE TIP TIME IN PRODUCTION
 NOTE TSMS3 TIME SINCE MILESTONE 3
 NOTE CMS4 CHANGE IN SCHEDULE
 NOTE
 A $TIP.K = TIPC * TM.K$ DT- 56
 C $TIPC = 24$ DT- 57
 NOTE
 NOTE TIP TIME IN PRODUCTION
 NOTE TM TIME MULTIPLIER
 NOTE
 NOTE TRANSFERS AND CANCELLATIONS
 NOTE
 R $APTR1.KL = AP1.K * TX1.K$ DT- 58
 NOTE
 NOTE APTR1 ACTUAL PROGRESS TRANSFER RATE
 NOTE AP1 ACTUAL PROGRESS
 NOTE TX1 TRANSFER SWITCH 1
 NOTE
 L $PASTP1.K = PASTP1.J + DT * (APTR1.JK - PASTR1.JK)$ DT- 59
 N $PASTP1 = PASTC$ DT- 60
 C $PASTC = 0$ DT- 61
 R $PASTR1.KL = PASTP1.K * TX2.K$ DT- 62
 NOTE
 NOTE PASTP1 PAST PROGRESS 1
 NOTE APTR1 ACTUAL PROGRESS TRANSFER RATE
 NOTE TX2 TRANSFER RATE2
 NOTE PASTR1 PAST PROGRESS TRANSFER RATE
 NOTE
 L $PSTPP1.K = PSTPP1.J + DT * (PPTX1.JK - PSTPT1.JK)$ DT- 63
 N $PSTPP1 = PSTPIC$ DT- 64
 C $PSTPIC = 0$ DT- 65
 R $PPTX1.KL = PP1.K * TX1.K$ DT- 66
 NOTE
 NOTE PSTPP PAST PLANNED PROGRESS
 NOTE PPTX1 PLANNED PROGRESS TRANSFER RATE
 NOTE PP1 PLANNED PROGRESS
 NOTE TX1 TRANSFER RATE
 NOTE
 R $PSTPT1.KL = PSTPP1.K * TX2.K$ DT- 67
 NOTE
 NOTE PSTPT1 PAST PLANNED PROGRESS TRANSFER RATE

NOTE PSTPP1 PAST PLANNED PROGRESS
 NOTE TX2 TRANSFER RATE 2
 NOTE
 R $CRTR1.KL=CR1.K*TX1.K$ DT- 68
 NOTE
 NOTE CRTR1 COST REPORTED TRANSFER RATE
 NOTE CR1 COST REPORTED
 NOTE TX1 TRANSFER RATE
 NOTE
 R $PCTR1.KL=PC1.K*TX1.K$ DT- 69
 NOTE
 NOTE PCTR1 PLANNED COST TRANSFER RATE
 NOTE PV1 PRODUCT VALUE
 NOTE TX1 TRANSFER RATE
 NOTE
 L $PPV1.K=PPV1.J+DT*(PVTRA1.JK-PPVTR1.JK)$ DT- 70
 N $PPV1=PPVIC$ DT- 71
 C $PPVIC=0$ DT- 72
 R $PVTRA1.KL=PPV1.K*TX1.K+ADVOC.K*USURGF.K$ DT- 73
 R $PPVTR1.KL=PPV1.K*TX2.K$ DT- 74
 NOTE
 NOTE PPV1 PAST PRODUCT VALUE
 NOTE PVTRA1 PRODUCT VALUE TRANSFER RATE
 NOTE PPVTR1 PAST PRODUCT VALUE TRANSFER RATE
 NOTE PPV1 PAST PRODUCT VALUE
 NOTE TX2 TRANSFER RATE
 NOTE
 R $APTR2.KL=AP2.K*TX2.K$ DT- 75
 NOTE
 NOTE APTR2 ACTUAL PROGRESS TRANSFER RATE
 NOTE AP2 ACTUAL PROGRESS
 NOTE TX2 TRANSFER SWITCH 2
 NOTE
 L $PASTP2.K=PASTP2.J+DT*(APTR2.JK-PASTR2.JK)$ DT- 76
 N $PASTP2=PASTC$ DT- 77
 C $PASTC=0$ DT- 78
 R $PASTR2.KL=PASTP2.K*TX3.K$ DT- 79
 NOTE DT- 80
 NOTE PASTP2 PAST PROGRESS 2
 NOTE APTR2 ACTUAL PROGRESS TRANSFER RATE
 NOTE TX3 TRANSFER RATE3
 NOTE PASTR2 PAST PROGRESS TRANSFER RATE
 NOTE
 L $PSTPP2.K=PSTPP2.J+DT*(PPTX2.JK-PSTPT2.JK)$ DT- 81
 N $PSTPP2=PSTP2C$ DT- 82
 C $PSTP2C=0$ DT- 83
 R $PPTX2.KL=PP2.K*TX2.K$ DT- 84
 NOTE
 NOTE PSTPP PAST PLANNED PROGRESS

NOTE	PPTX2	PLANNED PROGRESS TRANSFER RATE	
NOTE	PP2	PLANNED PROGRESS	
NOTE	TX2	TRANSFER RATE	
NOTE			
R	PSTPT2.KL=PSTPP2.K*TX3.K		DT- 85
NOTE			
NOTE	PSTPT2	PAST PLANNED PROGRESS TRANSFER RATE	
NOTE	PSTPP2	PAST PLANNED PROGRESS	
NOTE	TX3	TRANSFER RATE 3	
NOTE			
R	CRTR2.KL=CR2.K*TX2.K		DT- 86
R	PCTR2.KL=PC2.K*TX2.K		DT- 87
NOTE	CRTR2	COST REPORTED TRANSFER RATE	
NOTE	CR2	COST REPORTED	
NOTE	TX2	TRANSFER RATE	
NOTE	PCTR2	PLANNED COST TRANSFER RATE	
NOTE			
L	PPV2.K=PPV2.J+DT*(PVTR2.JK-PPVTR2.JK)		DT- 88
N	PPV2=PPV2C		DT- 89
C	PPV2C=0		DT- 90
R	PVTRA2.KL=PPV2.K*TX2.K*ADVOC.K*USURGF.K		DT- 91
R	PPVTR2.KL=PPV2.K*TX3.K		DT- 92
NOTE	PPV2	PAST PRODUCT VALUE	
NOTE	PVTRA2	PRODUCT VALUE TRANSFER RATE	
NOTE	PPVTR2	PAST PRODUCT VALUE TRANSFER RATE	
NOTE	TX3	TRANSFER RATE	
NOTE	ADVOC	ADVOCACY FACTOR	
NOTE	USURGF	US URGENCY FACTOR	
NOTE			
R	APTR3.KL=AP3.K*TX3.K		DT- 93
NOTE			
NOTE	APTR3	ACTUAL PROGRESS TRANSFER RATE	
NOTE	AP3	ACTUAL PROGRESS	
NOTE	TX3	TRANSFER SWITCH 3	
NOTE			
L	PASTP3.K=PASTP3.J+DT*(APTR3.JK-PASTR3.JK)		DT- 94
N	PASTP3=PASTC		DT- 95
C	PASTC=0		DT- 96
R	PASTR3.KL=PASTP3.K*TX4.K		DT- 97
NOTE			
NOTE	PASTP3	PAST PROGRESS 3	
NOTE	APTR3	ACTUAL PROGRESS TRANSFER RATE	
NOTE	TX4	TRANSFER RATE4	
NOTE	PASTR3	PAST PROGRESS TRANSFER RATE	
NOTE			
L	PSTPP3.K=PSTPP3.J+DT*(PPTX3.JK-PSTPT3.JK)		DT- 98
N	PSTPP3=PSTP3C		DT- 99
C	PSTP3C=0		DT- 100
R	PPTX3.KL=PP3.K*TX3.K		DT- 101

NOTE
NOTE PSTPP3 PAST PLANNED PROGRESS
NOTE PPTX3 PLANNED PROGRESS TRANSFER RATE
NOTE PP3 PLANNED PROGRESS
NOTE TX3 TRANSFER RATE
NOTE
R PSTPT3.KL=PSTPP3.K*TX4.K DT- 102
NOTE
NOTE PSTPT3 PAST PLANNED PROGRESS TRANSFER RATE
NOTE PSTPP3 PAST PLANNED PROGRESS
NOTE TX4 TRANSFER RATE 4
NOTE
R CTR3.KL=CR3.K*TX3.K DT- 103
NOTE
NOTE CTR3 COST REPORTED TRANSFER RATE
NOTE CR3 COST REPORTED
NOTE TX3 TRANSFER RATE
NOTE
R PCTR3.KL=PC3.K*TX3.K DT- 104
R PVTR3.KL=PV3.K*TX3.K*ADVOC.K*USURGF.K DT- 105
NOTE
NOTE PCR PLANNED COST TRANSFER RATE
NOTE PVTR3 PRODUCT VALUE TRANSFER RATE
NOTE PV3 PRODUCT VALUE
NOTE TX3 TRANSFER RATE
NOTE
L PPV3.K=PPV3.J+DT*(PVTR3.JK-PPVTR3.JK) DT- 106
N PPV3=PPV3C DT- 107
C PPV3C=0 DT- 108
NOTE
NOTE PPV3 PAST PRODUCT VALUE
NOTE PVTR3 PRODUCT VALUE TRANSFER RATE
NOTE PPVTR3 PAST PRODUCT VALUE TRANSFER RATE
NOTE
R PPVTR3.KL=PPV3.K*TX4.K DT- 109
NOTE
NOTE PPVTR3 PAST PRODUCT VALUE TRANSFER RATE
NOTE PPV3 PAST PRODUCT VALUE
NOTE TX4 TRANSFER RATE
NOTE

NOTE WEAPON SYSTEM OPERATION SECTOR
NOTE
L $WSO.K = WSO.J + DT * (WSMR.JK + WSDR.JK - WSSDR.JK - WSRR.JK)$ OP- 1
N $WSO = WSOC$ OP- 2
NOTE
C $WSOC = 90$ OP- 3
NOTE
NOTE WSO WEAPON SYSTEM OPERATIONAL
NOTE WSDR WEAPON SYSTEM DELIVERY RATE
NOTE WSMR WEAPON SYSTEM MAINTENANCE RATE
NOTE WSSDR WEAPON SYSTEMS SYSTEM DEFICIENCY RATE
NOTE WSRR WEAPON SYSTEMS RETIREMENT RATE
NOTE
R $WSMR.KL = WSORP.K + OSF.K$ OP- 4
NOTE
NOTE WSMR WEAPON SYSTEM MAINTENANCE RATE
NOTE WSN WEAPON SYSTEMS NOT OPERATIONAL
NOTE OSF OPERATING AND SUPPORT FACTOR
NOTE
L $WSN.K = WSN.J + DT * (WSSDR.JK - WSMR.JK)$ OP- 5
N $WSN = WSNC$ OP- 6
C $WSNC = 10$ OP- 7
NOTE
NOTE WSN WEAPON SYSTEMS NOT OPERATIONAL
NOTE WSSDR WEAPON SYSTEM SYSTEM DEFICIENCY RATE
NOTE WSMR WEAPON SYSTEM MAINTENANCE RATE
NOTE
R $WSSDR.KL = USE.K / MTBF.K$ OP- 8
NOTE
NOTE WSSDR SYSTEM DEFICIENCY RATE
NOTE WSO WEAPON SYSTEMS OPERATIONAL
NOTE USE USE
NOTE MTBF MEAN TIME BETWEEN FAILURES
NOTE OPERATING AND SUPPORT SECTION
NOTE
A $WSORP.K = WSO.K / (WSN.K + WSO.K)$ OP- 9
NOTE WSORP WEAPON SYSTEM OR PERCENT
NOTE WSO WEAPON SYSTEM OPERATIONAL
NOTE WSN WEAPON SYSTEM NOT OPERATIONAL
NOTE
A $OSR.K = WSORP.K + OSCF$ OP- 10
C $OSCF = .1$ OP- 11
NOTE
NOTE OSR O&S REQUIRED
NOTE WSORP WEAPON SYSTEM OR PERCENT
NOTE OSCF O&S COST FACTOR
NOTE
A $PFOS.K = TABHL(PFOS, WSORP.K, 0, 50, 10)$ OP- 12
T $PFOS = 1/1/1/1.15/1.82/2.68$ OP- 13

NOTE
 NOTE PFOS PRESSURE FOR O&S
 NOTE WSORP WEAPON SYSTEM OR PERCENT
 NOTE
 A $OSF.K = OSDAM.K * PFOS.K$ OP- 14
 NOTE OSF O&S FACTOR
 NOTE OSDAM O&S DOLLAR AVAILABLE MULTIPLIER
 NOTE PFOS PRESSURE FOR O&S
 NOTE
 A $OSDAM.K = TABLE(TABXT(OSDAMT, OSR.K / OSA.K(1), 0, 2, .27$ OP- 15
 T $OSDAMT = 1.0 / .98 / .9 / .82 / .7 / .52 / .38 / .29 / .26 / .24 / .22$ OP- 16
 NOTE
 NOTE OSDAM O&S DOLLAR AVAILABILITY MULTIPLIER
 NOTE OSA O&S AVAILABLE
 NOTE
 A $USE.K = WSORF.K * (WSO.K + WSN.K) * OPLAN.K$ OP- 17
 NOTE
 NOTE USE USE
 NOTE OPLAN OPERATIONAL PLAN
 NOTE WSORF WEAPON SYSTEM OR FACTOR
 NOTE
 A $OPLAN.K = TABHL(OPLANT, TIME.K, 0, 240, 20)$ OP- 18
 T $OPLANT = 1 / 1 / 1 / 1 / 1 / 1.2 / 1 / 1 / 1 / .9 / 1$ OP- 19
 NOTE
 NOTE OPLAN OPERATING PLAN
 NOTE
 NOTE
 T $WSORFT = 1 / 1 / .85 / .75 / .68 / .62$ OP- 20
 A $WSORF.K = TABHL(WSORFT, WSORP.K, 0, 50, 10)$ OP- 21
 NOTE
 NOTE WSORF WEAPON SYSTEM OR FACTOR
 NOTE WSORP WEAPON SYSTEM OR PERCENT
 NOTE
 A $MTBF.K = MTBFC * TE4D.K * MTBFM.K$ OP- 22
 C $MTBFC = 4$ OP- 23
 NOTE
 NOTE MTBF MEAN TIME BETWEEN FAILURE
 NOTE MTBFC MTBF INITIAL CONSTANT
 NOTE TE4D TECHNICAL EFFECTIVENESS DESIGNED(SMOOTHED)
 NOTE MTBFM MTBF AGE MULTIPLIER
 NOTE
 A $TE4D.K = SMOOTH(TE4.K, 18)$ OP- 24
 NOTE TE4D TECHNICAL EFFECTIVENESS DESIGNED (SMOOTHED)
 NOTE TE4 TECHNICAL EFFECTIVENESS DESIGNED
 NOTE
 A $MTBFM.K = TABHL(MTBFMT, WSAA.K, 5000, 15000, 2000)$ OP- 25
 T $MTBFMT = 1 / 1.05 / 1.13 / 1.25 / 1.6 / 1.9$ OP- 26
 NOTE
 NOTE MTBFM MTBF AGE MULTIPLIER

NOTE AWSA ACCUMULATED WEAPON SYSTEM AGE
 NOTE
 L $AWSA.K = AWSA.J + DT * (WSAR.JK - WSARR.JK)$ OP- 27
 M $AWSA = AWSAC$ OP- 28
 C $AWSAC = 0$ OP- 29
 NOTE
 NOTE AWSA ACCUMULATED WEAPON SYSTEM AGE
 NOTE WSAR WEAPON SYSTEM AGE RATE
 NOTE WSARR WEAPON SYSTEM AGE RESTORATION AND RETIREMENT RATE
 NOTE
 R $WSAR.KL = USE.K$ OP- 30
 NOTE
 NOTE WSAR WEAPON SYSTEM AGING RATE
 NOTE USE USE
 NOTE
 R $WSARR.KL = (MODF.K * AWSA.K) + (WSAA.K + WSRR.JK)$ OP- 31
 NOTE
 NOTE WSARR WEAPON SYSTEM AGE RESTORATION AND RETIREMENT RATE
 NOTE MODF MODIFICATION FACTOR
 NOTE AWSA ACCUMULATED WEAPON SYSTEM AGE
 NOTE WSAA WEAPON SYSTEM AVERAGE AGE
 NOTE WSRR WEAPON SYSTEM RETIREMENT RATE
 NOTE
 A $WSAA.K = AWSA.K / (WSO.K + WSN.K)$ OP- 32
 NOTE
 NOTE WSAA WEAPON SYSTEM AVERAGE AGE
 NOTE WSO WEAPON SYSTEMS OPERATIONAL
 NOTE WSN WEAPON SYSTEM NOT OPERATIONAL
 NOTE
 R $WSRR.KL = MIN(1, WSO.K * (ATTR + WSRF.K))$ OP- 33
 C $ATTR = .0016$ OP- 34
 NOTE
 NOTE WSRR WEAPON SYSTEM RETIREMENT RATE
 NOTE
 A $WSRF.K = TABHL(WSRFT, WSAA.K, 2500, 10000, 2500) * TM.K$ OP- 35
 T $WSRFT = 0.33 / .66 / 1.0$ OP- 36
 NOTE
 NOTE WSRF WEAPON SYSTEMS RETIREMENT FRACTION
 NOTE WSAA WEAPON SYSTEM AVERAGE AGE
 NOTE TM TIME MULTIPLIER

NOTE
 NOTE RESOURCES SECTOR
 NOTE
 NOTE
 L $TOTRES.K = TOTRES.J + DT * (DISCOV.JK - TRUSE.JK)$ RS- 1
 N $TOTRES = TOTRSC$ RS- 2
 C $TOTRSC = 100$ RS- 3
 NOTE
 NOTE TOTRES TOTAL RESOURCES
 NOTE DISCOV DISCOVERY RATE
 NOTE TRUSE TOTAL RESOURCE USE
 NOTE
 R $DISCOV.KL = DISCOF.K * TOTRES.K$ RS- 4
 NOTE
 NOTE DISCOV DISCOVERY RATE
 NOTE DISCOF DISCOVERY FRACTION
 NOTE TOTRES TOTAL RESOURCES
 NOTE
 A $DISCOF.K = TABHL(DISCOT, SEARCH.K, 0, 1, .02) / 12$ RS- 5
 T $DISCOT = .0 / .02 / .06 / .08 / .09 / .1$ RS- 6
 NOTE
 NOTE DISCOF DISCOVERY FRACTION
 NOTE SEARCH SEARCH FOR RESOURCES (SMOOTHED)
 NOTE
 A $SEARCH.K = SMOOTH(SEARC.K, 30)$ RS- 7
 A $SEARC.K = TABHL(SEARCT, TOTRES.K, 0, 100, 20)$ RS- 8
 T $SEARCT = 1 / .9 / .8 / .55 / .3 / .15$ RS- 9
 NOTE
 NOTE SEARCH SEARCH FOR RESOURCES (SMOOTHED)
 NOTE SEARC SEARCH FOR RESOURCES
 NOTE TOTRES TOTAL RESOURCES
 NOTE
 R $TRUSE.KL = GROWTH.K * TOTRES.K$ RS- 10
 NOTE
 NOTE TRUSE TOTAL RESOURCES USE
 NOTE GROWTH GROWTH FACTOR
 NOTE TOTRES TOTAL RESOURCES
 NOTE
 A $GROWTH.K = TABHL(GROWTT, TOTRES.K, 0, 100, 10) / 12$ RS- 11
 T $GROWTT = -50 / -30 / -15 / -5 / 0 / .007 / .019 / .025 / .03 / .03$ RS- 12
 NOTE
 NOTE GROWTH GROWTH FACTOR
 NOTE TOTRES TOTAL RESOURCES
 NOTE
 L $USRES.K = USRES.J + DT * (RAUS.JK - RDMUS.JK)$ RS- 13
 N $USRES = USRESC$ RS- 14
 C $USRESC = 33$ RS- 15
 NOTE
 NOTE USRES US RESOURCES

NOTE RAUS RESOURCES ALLOCATION FOR THE US
 NOTE RDMDUS RESOURCE DEMAND IN US
 NOTE
 R RAUS.KL=DISCOV.JK*ALLOCF RS- 16
 C ALLOCF=.33 RS- 17
 NOTE
 NOTE RAUS RESOURCES ALLOCATION FOR THE US
 NOTE DISCOV DISCOVERY FRACTION
 NOTE TRUSE TOTAL RESOURCE USE
 NOTE ALLOCF ALLOCATION FRACTION
 NOTE
 R RDMDUS.KL=(GROWTH.K-(EFFF.K/100))*USRES.K RS- 18
 NOTE
 NOTE RDMDUS RESOURCE DEMAND IN THE US
 NOTE GROWTH GROWTH FACTOR
 NOTE USRES US RESOURCES
 NOTE EFFF EFFICIENCY FACTOR
 NOTE
 A EFFF.K=DTC.K+TECHIF.K RS- 19
 NOTE
 NOTE EFFF EFFICIENCY FACTOR
 NOTE DTC DESIRE TO CONSERVE
 NOTE TECHIF TECHNICAL IMPROVEMENT FACTOR
 NOTE
 A USRESS.K=SMOOTH(USRES.K,10) RS- 20
 NOTE
 NOTE USRESS US RESOURCES (SMOOTHED)
 NOTE USRES US RESOURCES
 NOTE
 A DTC.K=TABHL(DTCT,USRESS.K,0,35,5) RS- 21
 T DTCT=-2./-.75/-.15/.4/.7/.9/1./1.0 RS- 22
 NOTE
 NOTE DTC DESIRE TO CONSERVE
 NOTE USRESS US RESOURCES (SMOOTHED)
 NOTE
 A TECHIF.K=TABHL(TECHIT,TECHCR.K,0,.2,.04) RS- 23
 T TECHIT=1/.5/.25/.15/.07/.04 RS- 24
 NOTE
 NOTE TECHIF TECHNICAL IMPROVEMENT FACTOR
 NOTE TECHCR TECHNOLOGY CHANGE RATE
 NOTE
 A RPFT.K=TABHL(RPFTT,USRESS.K,0,100,10) RS- 25
 T RPFTT=1./8/.7/.6/.5/.45/.4/.37/.35 RS- 26
 NOTE
 NOTE RPFT RESOURCES PRESSURE FOR TECHNOLOGY
 NOTE USRESS US RESOURCES (SMOOTHED)
 NOTE
 A RADPP.K=TABHL(RADPPT,TOTRES.K,0,100,10) RS- 27
 T RADPPT=0/.1/.25/.4/.35/.32/.3/.28/.27/.26/.25 RS- 28

NOTE
 NOTE RADPP RESOURCES AVAILABLE % FOR DEFENSE PRODUCTION
 NOTE TOTRES TOTAL RESOURCES
 NOTE
 A $RAADP.K = TOTRES.K * RADPP.K * AALLOC$ RS- 29
 C $AALLOC = .35$ RS- 30
 NOTE
 NOTE RADPP RESOURCES AVAILABLE FOR ALLIED DEFENSE PRODUCTION
 NOTE TOTRES TOTAL RESOURCES
 NOTE RADPP RESOURCES AVAILABLE % FOR DEFENSE PRODUCTION
 NOTE AALLOC ALLIED ALLOCATION PERCENT
 NOTE
 A $RAEDP.K = TOTRES.K * RADPP.K * EALLOC$ RS- 31
 C $EALLOC = .32$ RS- 32
 NOTE
 NOTE RADPP RESOURCES AVAILABLE FOR ENEMY DEFENSE PRODUCTION
 NOTE TOTRES TOTAL RESOURCES
 NOTE RADPP RESOURCES AVAILABLE % FOR DEFENSE PRODUCTION
 NOTE EALLOC ENEMY ALLOCATION
 NOTE
 A $RAUSDP.K = USRES.K * RPUSDP.K$ RS- 33
 NOTE RAUSDP RESOURCES AVAILABLE FOR US DEFENSE PRODUCTION
 NOTE USRES US RESOURCES
 NOTE RPUSDP RESOURCES % FOR US DEFENSE PRODUCTION
 NOTE
 A $RPUSDP.K = TABHL(RPUSDT, USRES.K, 0, 35, 5)$ RS- 34
 T $RPUSDT = 0, .2, .4, .3, .28, .27, .26, .25$ RS- 35
 NOTE RPUSDP RESOURCES % FOR US DEFENSE PRODUCTION
 NOTE USRES US RESOURCES
 NOTE

NOTE	TECHNOLOGY SECTOR	
NOTE		
L	TECH.K=TECH.J + DT*(TIR.JK-TLR.JK)	TC- 1
N	TECH=TECHC	TC- 2
C	TECHC=100	TC- 3
NOTE	TECH TECHNOLOGY AVAILABLE	
NOTE	TIR TECHNOLOGY INPUT RATE	
NOTE	TLR TECHNOLOGY LOSS RATE	
NOTE		
R	TIR.KL=TECH.K*(GROWTH.K+TDFS.K)	TC- 4
NOTE		
NOTE	TIR TECHNOLOGY INPUT RATE	
NOTE	GROWTH GROWTH FACTOR	
NOTE	TDFS TECHNOLOGY DISCOVERY FRACTION (SMOOTHED)	
NOTE		
A	TDFS.K=SMOOTH(TDF.K,TDFD)	TC- 5
C	TDFD=6	TC- 6
NOTE		
NOTE	TDFS TECHNOLOGY DISCOVERY FRACTION SMOOTHED	
NOTE	TDF TECHNOLOGY DISCOVERY FRACTION	
NOTE	TDFD TECHNOLOGY DISCOVERY FRACTION DELAY	
NOTE		
A	TDF.K=TABHL(SNT.K,0,1,.2)/12	TC- 7
T	TDFD=.01/.03/.07/.1/.12/.13	TC- 8
NOTE		
NOTE	TDF TECHNOLOGY DISCOVERY FRACTION	
NOTE		
A	SNT.K=TABHL(SNTT,TSP.K,0,.15,.03)	TC- 9
T	SNTT=.1/.15/.32/.52/.8/1.0	TC- 10
NOTE		
NOTE	SNT SEARCH FOR NEW TECHNOLOGY	
NOTE		
A	TSP.K=TP.K+OP.K	TC- 11
NOTE		
NOTE	TSP TOTAL SEARCH PRESSURE	
NOTE	TP TECHNOLOGY PRESSURE	
NOTE	OP OTHER PRESSURE	
NOTE		
A	TP.K=TABHL(TPT,TECH.K,0,100,10)	TC- 12
NOTE		
NOTE	TP TECHNOLOGY PRESSURE	
NOTE	TECH TECHNOLOGY AVAILABLE	
NOTE		
T	TPT=1/1/.9/.5/.27/.1	TC- 13
A	OP.K=SUNV(RDOC.K)/ECON*RPFT.K	TC- 14
C	ECON=1000	TC- 15
NOTE		
NOTE	OP OTHER PRESSURE	
NOTE	RDOC RESEARCH DOLLARS ON CONTRACT	

NOTE	ECON	ECONOMIC BASELINE	
NOTE	RPFT	RESOURCES PRESSURE FOR TECHNOLOGY	
NOTE	TSP	TOTAL SEARCH PRESSURE	
NOTE			
R	TLR.KL=TECH.K*TLF.K		TC- 16
R	TLF.K=SMOOTH(GROWTH.K,TLFD)		TC- 17
C	TLFD=60		TC- 18
NOTE			
NOTE	TECHCR	TECHNOLOGY CHANGE RATE	
NOTE	TIR	TECHNOLOGY INPUT RATE	
NOTE	TLF	TECHNICAL LOSS FACTOR	
NOTE	TLR	TECHNOLOGY LOSS RATE	
NOTE	TECH	TECHNOLOGY AVAILABLE	
NOTE			
A	TCF.K=TABHL(TCFT,TECHCR.K,0,.2,.02)		TC- 19
T	TCFT=2.0/1.95/1.85/1.7/1.45/1.0/1.67/.5/.35/.3/.25		TC- 20
A	TECHCR.K=(TIR.JK-TLR.JK)/TECH.K		TC- 21
NOTE			
NOTE	TCF	TECHNICAL COMPLEXITY FACTOR	
NOTE	TECHCR	TECHNOLOGY CHANGE RATE	
NOTE			

NOTE PRODUCTION SECTOR
NOTE
NOTE
NOTE ACTUAL PRODUCTION SECTION
NOTE
NOTE
L $WSP.K = WSP.J + DT * (WSPIR.JK - WSPR.JK)$ PR- 1
N $WSP = WSPC$ PR- 2
C $WSPC = 0$ PR- 3
NOTE
NOTE WSP WEAPON SYSTEM PRODUCTION
NOTE WSPIR WEAPON SYSTEM PRODUCTION INPUT RATE
NOTE WSPR WEAPON SYSTEM PRODUCTION RATE
NOTE
R $WSPIR.KL = \min(PCM4.K, RCWS.K)$ PR- 4
NOTE
NOTE WSPIR WEAPON SYSTEM PRODUCTION INPUT RATE
NOTE PCM4 PROGRAM
NOTE RCWS RESOURCE CONSTRAINED WEAPON SYSTEMS
NOTE
A $PCM4.K = \text{TABLE}(PCM1T, SCHEDP.K, 0, 1, .0833) * WSD4.K + DCP4.K * 12 /$ PR- 5
X $(TSMS3.K + TTPCC.K)$
A $SCHEDP.K = TSMS3.K / (TSMS3.K + TTPCC.K)$ PR- 6
NOTE
NOTE PCM4 PROGRAM
NOTE SCHEDP SCHEDULED PRODUCTION
NOTE WSD4 WEAPON SYSTEM DEVELOPMENT DECISION
NOTE TSMS3 TIME SINCE MILESTONE 3
NOTE TTPCC TIME TIL PRODUCTION CONTRACT COMPLETE
NOTE
A $RCWS.K = RAUSDP.K * WSRCF$ PR- 7
C $WSRCF = .1$ PR- -8
NOTE
NOTE RCWS RESOURCE CONSTRAINED WEAPON SYSTEMS
NOTE RAUSDP RESOURCES AVAILABLE FOR DEFENSE PRODUCTION
NOTE WSRCF WEAPON SYSTEM TO RESOURCES CONVERSION FACTOR
NOTE
R $WSPR.KL = \text{DELAY3}(WSPIR.JK, PRODT.K)$ PR- 9
NOTE
NOTE WSPR WEAPON SYSTEM PRODUCTION RATE
NOTE WSPIR WEAPON SYSTEM PRODUCTION INPUT RATE
NOTE PRODT PRODUCTION TIME
NOTE
A $PRODT.K = APRODT + PRODTA.K$ PR- 10
C $APRODT = 24$ PR- 11
NOTE
NOTE PRODT PRODUCTION TIME
NOTE APRODT AVERAGE PRODUCTION TIME
NOTE PRODTA PRODUCTION TIME ADJUSTOR

NOTE
A LCF.K=TABHL(LCFT,TWSP.K,0,500,40) PR- 12
T LCFT=1/1.15/1.35/1.57/1.69/1.78/1.87/1.96/2.92/2.11/2.20/ PR- 13
NOTE
NOTE LCF LEARNING CURVE FACTOR
NOTE TWSP TOTAL WEAPON SYSTEM PRODUCED
NOTE
L TWSP.K=TWSP.J+DT*(WSPR.JK-LCRR.JK) PR- 14
R LCRR.KL=TX4.K*TWSP.K PR- 15
N TWSP=TWSPC PR- 16
C TWSPC=0 PR- 17
NOTE
NOTE TWSP TOTAL WEAPON SYSTEM PRODUCED
NOTE WSPR WEAPON SYSTEM PRODUCTION RATE
NOTE LCRR LEARNING CURVE RELEASE RATE
NOTE
NOTE
N PRODT=24 PR- 18
A PRODTA.K=TTE.K*ME4*CPTS.K-LCF.K PR- 19
C ME4=1 PR- 20
A TTE.K=TE4.K*TCF.K PR- 21
A TE4.K=PASTP3.K/PSTPP3.K PR- 22
NOTE
NOTE PRODTA PRODUCTION TIME ADJUSTOR
NOTE LCF LEARNING CURVE FACTOR
NOTE TTE TOTAL TECHNICAL EFFECTIVENESS
NOTE ME4 MANAGEMENT EFFECTIVENESS CONSTANT
NOTE TE4 TECHNICAL EFFECTIVENESS
NOTE PASTP3 PAST PROGRESS
NOTE PSTPP PLANNED PAST PROGRESS TRANSFER RATE
A CPTS.K=SMOOTH(CPT.K,CPTD) PR- 23
C CPTD=1 PR- 24
A CPT.K=PRODT.K-PRODTD.K PR- 25
NOTE
NOTE CPTS CHANGE IN PRODUCTION TIME(SMOOTHED)
NOTE CPT CHANGE IN PRODUCTION TIME
NOTE PRODT PRODUCTION TIME
NOTE CPTD CHANGE IN PRODUCTION DELAY
NOTE DCAPR4 DESIRED CHANGE IN ACTUAL PRODUCTION RATE
NOTE APR4 ACTUAL PRODUCTION RATE
NOTE PRODTD PRODUCTION TIME DESIRED
NOTE
NOTE MARGINAL ANALYSIS TO DETERMINE DESIRED PRODUCTION TIME,
NOTE DESIRED TIME LATE, AND DESIRED COST FACTOR
NOTE
FOR P=1,10
A RWSP.K=NWSP.K-TWSP.K PR- 26
NOTE
NOTE RWSP REMAINING WEAPON SYSTEMS TO PRODUCE

NOTE NWSP NUMBER OF WEAPON SYSTEMS TO PRODUCE
 NOTE
 A $WSPRR.K(P) = RWSP.K / RTTPCC.K(P)$ PR- 27
 NOTE
 NOTE WSPRR WEAPON SYSTEM PRODUCTION RATE REQUIRED
 NOTE RWSP REMAINING WEAPON SYSTEMS TO PRODUCE
 NOTE TTPCC TIME TIL PRODUCTION CONTRACT COMPLETE
 NOTE WSPRR WEAPON SYSTEM PRODUCTION RATE REQUIRED
 NOTE
 A $RTTPCC.K(P) = TTPCC.K + T(P)$ PR- 28
 NOTE
 NOTE RTTPCC REVISED TIME TIL PRODUCTION CONTRACT COMPLETE
 NOTE TTPCC TIME TIL PRODUCTION CONTRACT COMPLETE
 NOTE T TIME LATE
 NOTE
 A $CF4.K(P) = TABHL(CFT4, WSPRR.K(P), .6, 2, .2)$ PR- 29
 NOTE
 NOTE CF4 COST FACTOR
 NOTE WSPRR WEAPON SYSTEM PRODUCTION RATE REQUIRED
 NOTE
 A $CP4.K(P) = CF4.K(P) * RTTPCC.K(P)$ PR- 30
 NOTE
 NOTE CP4 COST PENALTY
 NOTE CF4 COST FACTOR
 NOTE RTTPCC REVISED TIME TIL PRODUCTION CONTRACT COMPLETE
 NOTE
 A $SF4.K(P) = TABHL(SFT4, T(P), 1, 10, 1)$ PR- 31
 NOTE
 NOTE SF4 SCHEDULE FACTOR
 NOTE T TIME LATE
 NOTE
 A $SP4.K(P) = SF4.K(P) * T(P)$ PR- 32
 NOTE
 NOTE SP4 SCHEDULE PENALTY
 NOTE SF4 SCHEDULE FACTOR
 NOTE T TIME LATE
 NOTE
 A $TC4.K(P) = (CWF * CP4.K(P)) + (SWF * SP4.K(P))$ PR- 33
 NOTE
 NOTE TC4 TOTAL COST
 NOTE CWF COST WEIGHT FACTOR
 NOTE CP4 COST PENALTY
 NOTE SWF SCHEDULE WEIGHT FACTOR
 NOTE SP4 SCHEDULE PENALTY
 NOTE
 A $DATA4.K = DPR1(DCF4.K, DTL4.K, TC4.K, WSPRR.K, CP4.K, SP4.K)$ PR- 34
 NOTE DPR1 IS A FORTRAN FUNCTION TO FIND THE DESIRED
 NOTE TIME LATE (DTL) AND DESIRED COST FACTOR (DCF)
 NOTE

A	PRODTD.K=WSP.K/DWSPR.K	PR- 35
NOTE		
NOTE	PRODTD	PRODUCTION TIME DESIRED
NOTE	WSP	WEAPON SYSTEM PRODUCTION
NOTE	DWSPR	DESIRED WEAPON SYSTEM PRODUCTION RATE
NOTE		
L	WSIT.K=WSIT.J+DT*(WSPR.JK-WSDR.JK)	PR- 36
N	WSIT=WSITC	PR- 37
C	WSITC=0	PR- 38
R	WSDR.KL=DELAY3(WSPR.JK,2)	PR- 39
NOTE		
NOTE	WSIT	WEAPON SYSTEMS IN TRANSIT
NOTE	WSPR	WEAPON SYSTEM PRODUCTION RATE
NOTE	WSDR	WEAPON SYSTEMS DELIVERY RATE
NOTE		
L	PP4.K=PP4.J+DT*(PPGM4.JK-PPTX4.JK)	PR- 40
N	PP4=PP4C	PR- 41
C	PPIC=0	PR- 42
NOTE		
NOTE	PP4	PLANNED PRODUCTION
NOTE	PPR4	PLANNED PRODUCTION RATE
NOTE	PPTX4	PLANNED PRODUCTION TRANSFER RATE
NOTE		
R	PPGM4.KL=TABLE(PCMIT,PSCHD4.K,0,1,.003)*WSD4.K*12/TIP.K	PR- 43
X	*100/NWSP.K	
A	PSCHD4.K=TSMS3.K/TIP.K	PR- 44
NOTE		
A	PSE4.K=SWF*TABHL(PSET,ELF4.K,0,1,.2)+FLF4.K*CWF	PR- 45
NOTE	PSE4	PRESSURE FOR SCHEDULE EXTENSION
NOTE	ELF4	ESTIMATED LATE FACTOR
NOTE	FLF	FUNDS LIMIT FACTOR
NOTE	SWF	SCHEDULE WEIGHTING FACTOR
NOTE	CWF	COST WEIGHTING FACTOR
A	ELF4.K=DTL4.K/TTPCC.K	PR- 46
NOTE	ELF	ESTIMATED LATE FACTOR
NOTE	DTL4	DESIRED TIME LATE
NOTE	TTPCC	TIME TIL PRODUCTION CONTRACT COMPLETE
A	SEA4.K=CRPA4.K+PSE4.K/USURGF.K	PR- 47
A	SCD4.K=CLIP(SEA4.K,0,SEA4.K,.5)	PR- 48
NOTE		
NOTE	PSE4	PRESSURE FOR SCHEDULE EXTENSION
NOTE	CRPA	COST REPORTED PLANNED TO ACTUAL
NOTE	USURGF	US URGENCY FACTOR
NOTE	SCD4	SCHEDULE EXTENSION DECISION
NOTE	SEA4	SCHEDULE EXTENSION ADJUSTOR
NOTE		
A	SCDM4.K=CLIP(1,SCD4.K,SCD4.K,1)	PR- 49
A	SCHC.K=SCDM4.K*DTL4.K	PR- 50
A	CPCC.K=CLIP(SCHC.K,FC.K,SCHC.K,FC.K)	PR- 51

NOTE
 NOTE SCD4 SCHEDULE EXTENSION DECISION
 NOTE DTL4 DESIRED TIME LATE
 NOTE
 A $FC.K = \max(0, TTPCC.K / FLF4.K - TTPCC.K)$ PR- 52
 NOTE
 L $CR4.K = CR4.J + DT * (CRR4.JK - CRTR4.JK)$ PR- 53
 N $CR4 = CR4C$ PR- 54
 C $CR4C = 0$ PR- 55
 NOTE
 NOTE CR4 COST REPORTED
 NOTE CRR4 COST REPORTING RATE
 NOTE CRTR4 COST REPORTING TRANSFER RATE
 NOTE
 R $CRR4.KL = CE4 * DCFS4.K + PPGM4.JK + LCF.K$ PR- 56
 C $CE4 = 1$ PR- 57
 NOTE
 NOTE CRR4 COST REPORTED RATE
 NOTE CE4 COST ESTIMATING ERROR
 NOTE PPGM4 PLANNED PROGRAM
 NOTE DCFS4 DESIRED COST FACTOR (SMOOTHED)
 NOTE
 NOTE PR- 58
 A $DCFS4.K = \text{SMOOTH}(DCF4.K, DCF4D)$ PR- 59
 NOTE
 NOTE DCFS4 DESIRED COST FACTOR (SMOOTHED)
 NOTE DCF4 DESIRED COST FACTOR
 NOTE DCF4D DESIRED COST FACTOR DELAY
 NOTE
 L $PC4.K = PC4.J + DT * (PCR4.JK - PCTR4.JK)$ PR- 60
 NOTE
 NOTE PC4 PLANNED COSTS
 NOTE PCR4 PLANNED COST RATE
 NOTE PCTR4 PLANNED COST TRANSFER RATE
 NOTE
 R $PCR4.KL = PGM4.K / PTCR + CPC4.K$ PR- 61
 NOTE
 NOTE PCR4 PLANNED COST RATE
 NOTE PGM4 PROGRAM
 NOTE PTCR PRODUCTION TO COST RATIO
 NOTE
 A $TPC4.K = NWSP.K / PTCR + CPC4.K$ PR- 62
 NOTE
 NOTE TPC4 TOTAL PLANNED COST
 NOTE TPC4 TOTAL PRODUCTION GOAL
 NOTE PTCR PRODUCTION TO COST RATIO
 NOTE CPC4 CHANGE IN PLANNED COST
 NOTE
 NOTE

A	FLF4.K=	TABHL(FLFT,TWC4.K,0,10,1)	PR- 63
NOTE	FLF4	FUNDS LIMIT FACTOR	
NOTE	TWC4	TIME WEIGHTED COST	
A	TWC4.K=	TTPCC.K*CRPA4.K	PR- 64
NOTE	TWC4	TIME WEIGHTED COST	
NOTE	TTPCC	TIME TIL PRODUCTION CONTRACT COMPLETE	
NOTE	CRPA4	COST RATIO, PLANNED TO ACTUAL	
A	PIF4.K=	TABHL(PIFT,FLF4.K,0,1,4,2)	PR- 65
NOTE	PIF4	PRESSURE FOR INCREASED FUNDS	
NOTE	FLF4	FUNDS LIMIT FACTOR	
A	ITAF4.K=	FA4.K*PIF4.K*PRAP4.K*USURGF.K*MAIMPF	PR- 66
NOTE	ITAF4	INCLINATION TO APPROVE FUNDS	
NOTE	FA4	FUNDS AVAILABILITY	
NOTE	PIF4	PRESSURE FOR INCREASED FUNDS	
NOTE	PRAP	PROGRESS RATIO, ACTUAL TO PLANNED	
NOTE	USURGF	US URGENCY FACTOR	
NOTE	MAIMPF	MISSION AREA IMPORTANCE FACTOR	
A	FID4.K=	TABHL(FIDT,ITAF4.K,0,2,0,2)	PR- 67
NOTE	FID4	FUNDS INCREASE DECISION	
NOTE	ITAF4	INCLINATION TO APPROVE FUNDS	
A	CPC4.K=	FID4.K*ECC4.K	PR- 68
NOTE	CPC4	CHANGE IN PLANNED COST	
NOTE	FID4	FUNDS INCREASE DECISION	
NOTE	ECC4	ESTIMATED CHANGE IN COST	
A	ECC4.K=	CLIP(ICR4.K,0,ICR4.K,0)*(TSMS3.K+TTPCC.K)/PTCR	PR- 69
NOTE	ECC4	ESTIMATED CHANGE IN COST	
NOTE	CRPA4	COST RATIO, PLANNED TO ACTUAL	
NOTE	TSMS0	TIME SINCE MILESTONE 0	
NOTE	TTPCC	TIME TIL PRODUCTION CONTRACT COMPLETE	
NOTE	PTCR	PROGRESS TO COST RATIO	
A	ICR4.K=	1-1/CRPA4.K	PR- 70
A	FA4.K=	TABHL(FAT,FAF4.K,0,4,05)	PR- 71
NOTE			
NOTE	FA4	FUNDS AVAILABILITY	
NOTE	FAF4	FUNDS AVAILABILITY FACTOR	
A	FAF4.K=	ECC4.K/IDA.K(2)	PR- 72
NOTE	FAF	FUNDS AVAILABILITY FACTOR	
NOTE	ECC4	ESTIMATED CHANGE IN COST	
NOTE	RDA(2)	RESEARCH DOLLARS APPROPRIATED	

NOTE ALLIED SECTOR *****

NOTE

FOR IAA=1,120

N APLAN(IAA)=0 AL- 1

NOTE APLAN ALLIED PLANNED PRODUCTION

N FMSA(IAA)=0 AL- 2

NOTE FMSA FOREIGN MILITARY SALES AGREEMENTS

NOTE

N AWSP=0 AL- 3

L AWSP.K=AWSP.J+(DT)(AWSR.JK-AWSDR.JK) AL- 4

R AWSR.KL=FSHIFT(APLAN.K) AL- 5

A ADEL.R.K=24/AURGF.K AL- 6

R AWSDR.KL=DELAY3(AWSR.JK,ADEL.R.K) AL- 7

NOTE

NOTE AWSP ALLIED WEAPON SYSTEMS IN PRODUCTION

NOTE AWSR ALLIED WEAPON SYSTEMS PRODUCTION RATE

NOTE AWSDR ALLIED WEAPON SYSTEMS DELIVERY RATE

NOTE APLAN ALLIED PLANNED PRODUCTION

NOTE ADEL.R ALLIED DELAY RATE IN PRODUCTION

NOTE AURGF ALLIED URGENCY FACTOR

NOTE

L AWSO.K=AWSO.J+DT*(AWSDR.JK+AWSMR.JK-AWSUR.JK+AFMSDR.JK) AL- 8

N AWSO=5 AL- 9

NOTE

NOTE AWSO ALLIED WEAPON SYSTEMS OPERATIONAL

NOTE AWSDR ALLIED WEAPON SYSTEMS DELIVERY RATE

NOTE AWSMR ALLIED WEAPON SYSTEMS MAINTENANCE RATE

NOTE AWSUR ALLIED WEAPON SYSTEMS USE RATE

NOTE AFMSDR ALLIED FOREIGN MILITARY SALES DELIVERY RATE

NOTE

N AWSN=1 AL- 10

L AWSN.K=AWSN.J+(DT)(AWSUR.JK-AWSMR.JK-AWSRR.JK) AL- 11

R AWSMR.KL=AWSN.K*AMPCT AL- 12

R AWSUR.KL=AWSO.K*AUPCT AL- 13

R AWSRR.KL=ARETC*AWSN.K AL- 14

NOTE

NOTE AWSN ALLIED WEAPON SYSTEMS NON-OPERATIONAL

NOTE AWSUR ALLIED WEAPON SYSTEMS USE RATE

NOTE AWSMR ALLIED WEAPON SYSTEMS MAINTENANCE RATE

NOTE AWSRR ALLIED WEAPON SYSTEMS RETIREMENT RATE

NOTE AMPCT ALLIED PERCENTAGE OF WEAPONS REPAIRED

NOTE AUPCT ALLIED PERCENTAGE OF WEAPONS USED

NOTE ARETC ALLIED RETIREMENT CONSTANT

NOTE

N WSFAI=0 AL- 15

L WSFAI.K=WSFAI.J+DT*(ATXR.JK-AFMSDR.JK) AL- 16

R AFMSDR.KL=DELAY3(ATXR.JK,24) AL- 17

R ATXR.KL=FSHIFT(FMSA.K) AL- 18

NOTE

NOTE WSFAI WEAPON SYSTEMS FOR ALLIED INVENTORIES
 NOTE ATXR ALLIED TRANSFER RATE
 NOTE AFMSDR ALLIED FOREIGN MILITARY SALES DELIVERY RATE
 NOTE FMSA FOREIGN MILITARY SALES AGREEMENTS
 NOTE
 C AMPCT=.85 AL- 19
 NOTE AMPCT ALLIED PERCENTAGE OF WEAPONS REPAIRED
 C AUPCT=.20 AL- 20
 NOTE AUPCT ALLIED PERCENTAGE OF WEAPONS USED
 C ARETC=.002 AL- 21
 NOTE ARETC ALLIED RETIREMENT CONSTANT
 C ADESWF=1.0 AL- 22
 NOTE ADESWF ALLIED DESIRE FOR WEAPON SYSTEMS
 C ACPWS=75 AL- 23
 NOTE ACPWS ALLIED CAPABILITY PER WEAPON SYSTEM
 NOTE
 A ADEF.K(MO)=MAX(ADIF.K(MO),0)*ADPCT.K AL- 24
 A ADIF.K(MO)=ECAP.K(MO)-ACAP.K(MO)-USCAP.K(MO) AL- 25
 NOTE
 NOTE ADEF ALLIED DEFICIENCY
 NOTE ADIF ALLIED DIFFERENCE IN CAPABILITY
 NOTE ADPCT ALLIED PERCENTAGE OF DEFICIENCY
 NOTE ECAP ENEMY CAPABILITY
 NOTE ACAP ALLIED CAPABILITY
 NOTE USCAP US CAPABILITY
 NOTE
 A AURGF.K=TABLE(EWGT,AURG.K/12,0,10,1) AL- 26
 A AURG.K=URGENCY(ADEF.K) AL- 27
 NOTE
 NOTE AURGF ALLIED URGENCY FACTOR
 NOTE EWGT URGENCY WEIGHTING TABLE
 NOTE AURG ALLIED URGENCY--TIME TO FIRST DEFICIENCY
 NOTE
 A APTHR.K(MO)=(EINT.K-USINT.K)*ADEF.K(MO) AL- 28
 NOTE
 NOTE APTHR ALLIED PERCEIVED THREAT
 NOTE EINT ENEMY INTENT TO USE FORCE
 NOTE ADEF ALLIED DEFICIENCY
 A ADWSL.K(MO)=ADESWF*APTHR.K(MO)/ACPWS AL- 29
 NOTE
 NOTE ADWSL ALLIED DESIRED WEAPON SYSTEMS LEVEL
 NOTE ADESWF ALLIED DESIRE FOR WEAPONS FACTOR
 NOTE APTHR ALLIED PERCEIVED THREAT
 NOTE ACPWS ALLIED CAPABILITY PER WEAPON SYSTEM
 NOTE
 A AINT.K=TABHL(AWGT,AINTF.K,-1,1,.2) AL- 30
 A AINTF.K=SMOOTH(SUM(APTHR.K)/120,3) AL- 31
 N AINTF=.85 AL- 32
 T AWGT=0/0/.05/.10/.25/.45/.85/.99/-.60/-1.00 AL- 33

NOTE
NOTE AINT ALLIED INTENT TO USE FORCE
NOTE AINTF ALLIED INTENT FACTOR
NOTE APTHR ALLIED PERCEIVED THREAT
NOTE
A $ADPCT.K = TABLE(APFT, AINT.K, -1, 1, .2)$ AL- 34
T $APFT = -1.0 / -.86 / -.25 / -.15 / -.05 / .0 / .05 / .15 / .25 / .60 / .65$ AL- 35
NOTE
NOTE ADPCT ALLIED PERCENTAGE OF DEFICIENCY
NOTE AINT ALLIED INTENT
NOTE
C ACOSWS=5.5E6 AL- 36
A $APPC.K = ACAPDP.K / ACOSWS$ AL- 37
NOTE
NOTE ACOSWS ALLIED COST PER WEAPON SYSTEM
NOTE APPC ALLIED PROJECTED PRODUCTION CAPACITY
NOTE ACAPDP ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE
FOR IA1=1,36
L $APLAN.K(IA1) = APLAN.J(IA1) + DT * (APACC.JK(IA1))$ AL- 38
R $APACC.KL(IA1) = MIN(ASDEV.K(IA1), APPC.K)$ AL- 39
A $ASDEV.K(IA1) = SUMV(ADWSL.K(*), 1, 36) * CLIP(1, 0, T(IA1), 12) /$ AL- 40
X (36-AURC.K)
NOTE
NOTE APLAN ALLIED PLANNED PRODUCTION
NOTE APACC ALLIED PRODUCTION ACCELERATOR
NOTE ASDEV ALLIED SCHEDULE DEVIATION
NOTE APPC ALLIED PROJECTED PRODUCTION CAPACITY
NOTE ADWSL ALLIED DESIRED WEAPON SYSTEMS LEVEL
NOTE AURC ALLIED URGENCY--TIME TO FIRST DEFICIENCY
NOTE T TIME
NOTE
L $FMSA.K(MO) = FMSA.J(MO) + DT * (FMSBR.JK(MO))$ AL- 41
NOTE
NOTE FMSA FOREIGN MILITARY SALES AGREEMENT
NOTE FMSBR FOREIGN MILITARY SALES BUY RATE
NOTE
FOR IA2=37,120
L $APLAN.K(IA2) = APLAN.J(IA2) + DT * (ALRADJ.JK(IA2-36))$ AL- 42
R $ALRADJ.KL(IA2-36) = CLIP(NAWS.K(IA2), 0, ADECP.K, ADECB.K)$ AL- 43
NOTE
NOTE APLAN ALLIED PLANNED PRODUCTION
NOTE ALRADJ ALLIED LONG-RANGE ADJUSTMENT RATE
NOTE NAWS NUMBER OF ALLIED WEAPON SYSTEMS
NOTE ADECP ALLIED DECISION TO PRODUCE
NOTE ADECB ALLIED DECISION TO BUY
NOTE
A $AGEF.K = TABHL(AGFT, AAGE.K / 12, 0, 10, 1)$ AL- 44
T $AGFT = 1 / 1 / 1 / 1 / 1 / 1.25 / 1.75 / 2.5 / 3.25 / 4.15 / 6.0$ AL- 45

NOTE
 NOTE AGEF AGE FACTOR
 NOTE AAGE AVERAGE AGE
 NOTE
 A $STDF.K = TABHL(STDFT, APSWS.K, \emptyset, 1, 1)$ AL- 46
 T $STDFT = 2/1.75/1/.85/.65/.43/.3\emptyset/.23/.17/.12/.05$ AL- 47
 NOTE
 NOTE STDF STANDARDIZATION FACTOR
 NOTE APSWS ALLIED PERCENTAGE OF STANDARDIZED WEAPON SYSTEMS
 NOTE
 A $AQF.K(M\emptyset) = TABHL(AQUAL, T(M\emptyset) * AGEF.K / STDF.K, \emptyset, 12\emptyset, 12)$ AL- 48
 T $AQUAL = 1.\emptyset/.99/.99/.98/.95/.85/.7/.55/.35/.25/.1$ AL- 49
 NOTE
 NOTE AQF ALLIED QUALITY FACTOR
 NOTE T TIME
 NOTE AGEF AGE FACTOR
 NOTE STDF STANDARDIZATION FACTOR
 NOTE
 A $APSWS.K = ASTINV.K / (AWSO.K + AWSN.K)$ AL- 50
 N $ASTINV = \emptyset$ AL- 51
 L $ASTINV.K = ASTINV.J + DT * (ASTR.JK)$ AL- 52
 R $ASTR.KL = FMSA.K(1) + SWITCH(\emptyset, AWSDR.JK, COFAC.K)$ AL- 53
 NOTE
 NOTE APSWS ALLIED PERCENTAGE OF STANDARDIZED WEAPON SYSTEMS
 NOTE ASTINV ALLIED STANDARDIZED INVENTORY
 NOTE AWSO ALLIED WEAPON SYSTEMS OPERATIONAL
 NOE AWSN ALLIED WEAPON SYSTEMS NON-OPERATIONAL AL- 54
 NOTE ASTR ALLIED STANDARDIZATION TRANSFER RATE
 NOTE FMSA FOREIGN MILITARY SALES AGREEMENTS
 NOTE AWSDR ALLIED WEAPON SYSTEMS DELIVERY RATE
 NOTE COFAC COPRODUCTION FACTOR
 NOTE
 A $ACAP.K(M\emptyset) = (AWSO.K + AWSN.K + AWSP.K + SUMVIAPLAN.K(*), 1, T(M\emptyset)) * ACPWS * AQF.K(M\emptyset)$ AL- 55
 X
 NOTE
 NOTE ACAP ALLIED CAPABILITY
 NOTE AWSO ALLIED WEAPON SYSTEMS OPERATIONAL
 NOTE AWSN ALLIED WEAPON SYSTEMS NON-OPERATIONAL
 NOTE AWSP ALLIED WEAPON SYSTEMS IN PRODUCTION
 NOTE APLAN ALLIED PLANNED PRODUCTION
 NOTE ACPWS ALLIED CAPABILITY PER WEAPON SYSTEM
 NOTE AQF ALLIED QUALITY FACTOR
 NOTE
 A $ARUCWS.K = RAADP.K * RESCF.K$ AL- 56
 A $RESCF.K = TABXTIRSCFT, RAADP.K, \emptyset, 1\emptyset\emptyset, 1\emptyset)$ AL- 57
 T $RESCFT = 1.E6/1.E4/1\emptyset\emptyset/65\emptyset/4\emptyset\emptyset/28\emptyset/2\emptyset\emptyset/14\emptyset/8\emptyset/4\emptyset/1\emptyset$ AL- 58
 NOTE
 NOTE ARUCWS ALLIED RESOURCE UNIT CONSTRAINT PER WEAPON SYSTEM
 NOTE RAADP RESOURCES ALLOWED FOR ALLIED DEFENSE PRODUCTION

NOTE RESCF RESOURCE COST FACTOR
NOTE
A $ACAPDP.K = \min(ARUCWS.K, ACNP.K, APCNPD)$ AL- 59
NOTE
NOTE ACAPDP ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE ARUCWS ALLIED RESOURCE UNIT CONSTRAINT PER WEAPON SYSTEM
NOTE ACNP ALLIED GROSS NATIONAL PRODUCT
NOTE APCNPD ALLIED PERCENT OF GNP TO DEFENSE
NOTE
C $APCNPD = .003$ AL- 60
N $ACNP = 1E10$ AL- 61
L $ACNP.K = ACNP.J + DT * (ACNPGR.JK)$ AL- 62
R $ACNPGR.KL = ACNP.K * ACNPGF$ AL- 63
C $ACNPGF = .002$ AL- 64
NOTE
NOTE APCNPD ALLIED PERCENT OF GNP TO DEFENSE
NOTE ACNP ALLIED GROSS NATIONAL PRODUCT (GNP)
NOTE ACNPGR ALLIED GNP GROWTH RATE
NOTE ACNPGF ALLIED GNP GROWTH FACTOR
NOTE
NOTE
A $COFAC.K = ACOPR.K * USCOPA.K$ AL- 65
A $ACOPR.K = \text{CLIP}(1, 0, ACAPDP.K, ADECP.K)$ AL- 66
NOTE
NOTE COFAC COPRODUCTION FACTOR
NOTE ACOPR ALLIED COPRODUCTION REQUEST
NOTE USCOPA US COPRODUCTION AGREEMENT
NOTE ACAPDP ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE ADECP ALLIED DECISION TO PRODUCE
NOTE
A $ACOAWS.K = \text{SUM}(ADWSL.K) * ACOSWS$ AL- 67
A $ACOUWS.K = \text{SUM}(APTHR.K) * ACBWS.K / USCPS.K$ AL- 68
A $ACOMWS.K = \text{SUM}(NAWS.K) * ACOSWS + \text{SUM}(NUSWS.K) * ACBWS.K$ AL- 69
NOTE
NOTE ACOAWS ALLIED COST FOR ALLIED WEAPON SYSTEMS
NOTE ADWSL ALLIED DESIRED WEAPON SYSTEMS LEVEL
NOTE ACOSWS ALLIED COST PER WEAPON SYSTEM
NOTE ACOUWS ALLIED COST FOR US WEAPON SYSTEMS
NOTE APTHR ALLIED PERCEIVED THREAT
NOTE ACBWS ALLIED COST TO BUY WEAPON SYSTEMS
NOTE USCPS US CAPABILITY PER WEAPON SYSTEM
NOTE NAWS NUMBER OF ALLIED WEAPON SYSTEMS PLANNED
NOTE NUSWS NUMBER OF US WEAPON SYSTEMS PLANNED
NOTE
A $ADECB.K = \min(ACOUWS.K, ACOMWS.K)$ AL- 70
A $ADECP.K = \text{SMOOTH}(\min(ADECB.K, ACOAWS.K), 1)$ AL- 71
NOTE
NOTE ADECB ALLIED DECISION TO BUY
NOTE ACOUWS ALLIED COST FOR US WEAPON SYSTEMS

NOTE ACOMWS ALLIED COST FOR MIXED WEAPON SYSTEMS INVENTORY
 NOTE ADECP ALLIED DECISION TO PRODUCE
 NOTE ACOAWS ALLIED COST FOR ALLIED WEAPON SYSTEMS
 NOTE
 A $NAWS.K(MO) = CLIP(APTHR.K(MO) - USCPWS.K * COMP.K(MO), ADWSL.K(MO), AL - 72$
 X $ADECP.K, ACOAWS.K)$
 NOTE
 NOTE NAWS NUMBER OF ALLIED WEAPON SYSTEMS PLANNED
 NOTE APTHR ALLIED PERCEIVED THREAT
 NOTE USCPWS US CAPABILITY PER WEAPON SYSTEM
 NOTE COMP COMPUTED TRADEOFF FACTOR
 NOTE ADWSL ALLIED DESIRED WEAPON SYSTEMS LEVEL
 NOTE ADECP ALLIED DECISION TO PRODUCE
 NOTE ACOAWS ALLIED COST FOR ALLIED WEAPON SYSTEMS
 NOTE
 A $NUSWS.K(MO) = CLIP(ACPWS * COMP.K(MO), APTHR.K(MO) / USCPWS.K, AL - 73$
 X $ADECP.K, ACOUWS.K)$
 NOTE
 NOTE NUSWS NUMBER OF US WEAPON SYSTEMS PLANNED
 NOTE ACPWS ALLIED CAPABILITY PER WEAPON SYSTEM
 NOTE COMP COMPUTED TRADEOFF FACTOR
 NOTE APTHR ALLIED PERCEIVED THREAT
 NOTE USCPWS US CAPABILITY PER WEAPON SYSTEM
 NOTE ADECP ALLIED DECISION TO PRODUCE
 NOTE ACOUWS ALLIED COST FOR US WEAPON SYSTEMS
 NOTE
 A $COMP.K(MO) = (ACOSWS * APTHR.K(MO) - ACAPDP.K) / (USCPWS.K * ACOSWS AL - 74$
 X $- ACPWS * ACBWS.K)$
 NOTE
 NOTE COMP COMPUTED TRADEOFF FACTOR
 NOTE ACOSWS ALLIED COST PER WEAPON SYSTEM
 NOTE APTHR ALLIED PERCEIVED THREAT
 NOTE ACAPDP ALLIED CAPACITY FOR DEFENSE PRODUCTION
 NOTE USCPWS US CAPABILITY PER WEAPON SYSTEM
 NOTE ACPWS ALLIED CAPABILITY PER WEAPON SYSTEM
 NOTE ACBWS ALLIED COST TO BUY WEAPON SYSTEMS
 NOTE
 R $FMSBR.KL(MO) = CLIP(NUSWS.K(MO), 0, ADECP.K, ADECB.K) AL - 75$
 NOTE
 NOTE FMSBR FOREIGN MILITARY SALES BUY RATE
 NOTE NUSWS NUMBER OF US WEAPON SYSTEMS PLANNED
 NOTE ADECP ALLIED DECISION TO PRODUCE
 NOTE ADECB ALLIED DECISION TO BUY
 NOTE
 N $AAGE = 60 AL - 76$
 N $FLTAGE = AAGE * WSO AL - 77$
 L $FLTAGE.K = FLTAGE.J + DT * (ACER.JK) AL - 78$
 R $ACER.KL = AWSO.K + AWSN.K - AWSRR.JK * AAGE.K * DISTK AL - 79$
 C $DISTK = 2 AL - 80$

NOTE
 NOTE AAGE AVERAGE AGE OF ALLIED WEAPONS
 NOTE FLTAGE COMBINED AGE OF ALLIED FLEET
 NOTE AWSO ALLIED WEAPON SYSTEMS OPERATIONAL
 NOTE AGER ALLIED AGE RATE
 NOTE AWSN ALLIED WEAPON SYSTEMS NON-OPERATIONAL
 NOTE AWSRR ALLIED WEAPON SYSTEMS RETIREMENT RATE
 NOTE DISTK DISTRIBUTION CONSTANT

NOTE

A $AAGE.K = FLTAGE.K / (AWSO.K + AWSN.K)$

AL- 81

NOTE

NOTE AAGE AVERAGE AGE OF ALLIED WEAPONS
 NOTE FLTAGE COMBINED AGE OF ALLIED FLEET
 NOTE AWSO ALLIED WEAPON SYSTEMS OPERATIONAL
 NOTE AWSN ALLIED WEAPON SYSTEMS NON-OPERATIONAL
 NOTE

NOTE ***** ENEMY SECTOR *****
FOR IE=1,120
N EPLAN(IE)=0 EN- 1
NOTE
N EWSP=20 EN- 2
L EWSP.K=EWSP.J+(DT)(EWSR.JK-EWSDR.JK) EN- 3
R EWSDR.KL=DELAY3(EWSR.JK,EDEL.R.K) EN- 4
R EWSR.KL=FSHIFT(EPLAN.K) EN- 5
NOTE
NOTE EPLAN ENEMY PLANNED PRODUCTION
NOTE EWSP ENEMY WEAPON SYSTEMS PRODUCTION
NOTE EWSR ENEMY WEAPON SYSTEMS PRODUCTION INPUT RATE
NOTE EWSDR ENEMY WEAPON SYSTEMS DELIVERY RATE
NOTE
A EDEL.R.K=24/EURGF.K EN- 6
NOTE
NOTE EDEL.R ENEMY PRODUCTION DELAY FACTOR
NOTE EURGF ENEMY URGENCY FACTOR
NOTE
N EWSO=100 EN- 7
L EWSO.K=EWSO.J+(DT)(EWSR.JK+EWSMR.JK-EWSUR.JK) EN- 8
NOTE
NOTE EWSO ENEMY WEAPON SYSTEMS OPERATIONAL
NOTE EWSDR ENEMY WEAPON SYSTEMS DELIVERY RATE
NOTE EWSMR ENEMY WEAPON SYSTEMS MAINTENANCE RATE
NOTE EWSUR ENEMY WEAPON SYSTEMS USE RATE
NOTE
N EWSN=10 EN- 9
L EWSN.K=EWSN.J+(DT)(EWSUR.JK-EWSMR.JK-EWSRR.JK) EN- 10
NOTE
NOTE EWSN ENEMY WEAPON SYSTEMS NON-OPERATIONAL
NOTE EWSUR ENEMY WEAPON SYSTEMS USE RATE
NOTE EWSMR ENEMY WEAPON SYSTEMS MAINTENANCE RATE
NOTE EWSRR ENEMY WEAPON SYSTEMS RETIREMENT RATE
NOTE
R EWSUR.KL=EUPCT*EWSO.K EN- 11
NOTE
NOTE EUPCT ENEMY PERCENTAGE OF WEAPON SYSTEMS USED
NOTE EWSO ENEMY WEAPON SYSTEMS OPERATIONAL
NOTE
R EWSMR.KL=EMPCT*EWSN.K EN- 12
NOTE
NOTE EMPCT ENEMY PERCENTAGE OF WEAPONS REPAIRED
NOTE
R EWSRR.KL=EWSN.K*.002/EURGF.K EN- 13
NOTE
NOTE EWSRR ENEMY WEAPON SYSTEMS RETIREMENT RATE
NOTE EURGF ENEMY URGENCY FACTOR
NOTE EWSN ENEMY WEAPON SYSTEMS NON-OPERATIONAL

R EPACC.KL=EURGF.K*SUMV(EDEF.K(*),1,36)/((36-EURG.K)*ECAPWS) EN- 14
 NOTE
 NOTE EPACC ENEMY PRODUCTION ACCELERATOR
 NOTE EURGF ENEMY URGENCY FACTOR
 NOTE EDEF ENEMY DEFICIENCY
 NOTE EURG ENEMY URGENCY--TIME TO FIRST DEFICIENCY
 NOTE ECAPWS ENEMY CAPABILITY PER WEAPON SYSTEM
 NOTE
 C ECAPWS=75 EN- 15
 NOTE ECAPWS ENEMY CAPABILITY PER WEAPON SYSTEM
 C EDESWF=1.15 EN- 16
 NOTE EDESWF ENEMY DESIRE FOR WEAPONS FACTOR
 C EUPCT=.20 EN- 17
 NOTE EUPCT ENEMY PERCENTAGE OF WEAPON SYSTEMS USED
 C EMPCT=.90 EN- 18
 NOTE EMPCT ENEMY PERCENTAGE OF WEAPON SYSTEMS REPAIRED
 NOTE
 FOR MO=1,120
 A EDEF.K(MO)=MAX(EDIF.K(MO),0.0) EN- 19
 NOTE
 NOTE EDEF ENEMY DEFICIENCY
 NOTE EDIF ENEMY DIFFERENCE IN CAPABILITY
 NOTE
 A EDIF.K(MO)=USCAP.K(MO)+ACAP.K(MO)-ECAP.K(MO) EN- 20
 NOTE
 NOTE EDIF ENEMY DIFFERENCE IN CAPABILITY
 NOTE USCAP US CAPABILITY
 NOTE ACAP ALLIED CAPABILITY
 NOTE ECAP ENEMY CAPABILITY
 NOTE
 A EURG.K=URGENCY(EDEF.K) EN- 21
 NOTE
 NOTE EURG ENEMY URGENCY--TIME TO FIRST DEFICIENCY
 NOTE EDEF ENEMY DEFICIENCY
 NOTE
 T EWGT=2.0/1.75/1.35/1.15/1.05/1./99/.98/.97/.96 EN- 22
 A EURGF.K=TABLE(EWGT,EURG.K,0,120,12) EN- 23
 NOTE
 NOTE EURGF ENEMY URGENCY FACTOR
 NOTE EURG ENEMY URGENCY--TIME TO FIRST DEFICIENCY
 NOTE
 NOTE
 A ECAP.K(MO)=(EWSP.K+EWSO.K+EWSN.K+SUMVIEPLAN.K(*), EN- 24
 X 1,T(MO)))*ECAPWS
 NOTE
 NOTE ECAP ENEMY CAPABILITY
 NOTE EWSP ENEMY WEAPON SYSTEMS IN PRODUCTION
 NOTE EWSO ENEMY WEAPON SYSTEMS OPERATIONAL
 NOTE EWSN ENEMY WEAPON SYSTEMS NON-OPERATIONAL

NOTE EPLAN ENEMY PLAN FOR WEAPON SYSTEMS PRODUCTION
 NOTE T TIME TABLE
 NOTE ECAPWS ENEMY CAPABILITY PER WEAPON SYSTEM
 NOTE
 A $EINT.K = TABHL(EINTT, SUM(EPTHR) / 120, -1, 1, .2)$ EN- 25
 NOTE
 NOTE EINT ENEMY INTENT
 NOTE EPTHR ENEMY PERCEIVED THREAT
 NOTE
 T $EINTT = 1.99 / 1.7 / 1.3 / 1.15 / 1.05 / 1 / 1.05 / 1.15 / 1.3 / 1.7 / 1.99$ EN- 26
 A $EINTF.K = SMOOTH(SUM(EPTHR) / 120, 3)$ EN- 27
 N $EINTF = 1$ EN- 28
 NOTE
 NOTE EINTF ENEMY INTENT FACTOR
 NOTE EPTHR ENEMY PERCEIVED THREAT
 NOTE
 A $EDWSL.K(MO) = EDESWF * EPTHR.K(MO) / ECAPWS$ EN- 29
 NOTE
 NOTE EDWSL ENEMY DESIRED WEAPON SYSTEMS LEVEL
 NOTE EDESWF ENEMY DESIRE FOR WEAPONS FACTOR
 NOTE EPTHR ENEMY PERCEIVED THREAT
 NOTE ECAPWS ENEMY CAPABILITY PER WEAPON SYSTEM
 NOTE
 A $EPTHR.K(MO) = (USINT.K + AINT.K) * EDEF.K(MO)$ EN- 30
 NOTE
 NOTE EPTHR ENEMY PERCEIVED THREAT
 NOTE USINT US INTENT
 NOTE AINT ALLIED INTENT
 NOTE EDEF ENEMY DEFICIENCY
 FOR ME=1,36
 L $EPLAN.K(ME) = EPLAN.J(ME) + (DT) * (EPACC.JK)$ EN- 31
 NOTE
 NOTE EPLAN ENEMY PLAN FOR WEAPON SYSTEMS PRODUCTION
 NOTE EPACC ENEMY PRODUCTION ACCELERATOR
 NOTE
 FOR MEE=37,120
 L $EPLAN.K(MEE) = EPLAN.J(MEE) + DT * (EADJ.JK(MEE-36))$ EN- 32
 R $EADJ.KL(MEE-36) = EDWSL.K(MEE)$ EN- 33
 NOTE
 NOTE EADJ ENEMY ADJUSTMENT RATE
 NOTE

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NOTE      *****  FORTRAN SUBROUTINES  *****
NOTE
NOTE
X  REAL FUNCTION URGENCY (ARRAY)
COMMON X(109),T(120),X1(196),X2(167),PRR1(10),X3(10)      SUB- 1
COMMON CF1(10),X4(30),TC2(10),PRR3(10),X5(10),CF3(10)      SUB- 2
COMMON X6(30),TC3(10),EPLAN(120),X7(684),APLAN(120)        SUB- 3
COMMON FMSA(120),X8(600),X9(601),WSPRR(10),Y(20)           SUB- 4
COMMON CP4(10),Y1(10),SP4(10),TC4(10),X12(2)               SUB- 5
DIMENSION ARRAY(120)                                       SUB- 6

NOTE
NOTE      FUNCTION URGENCY FINDS THE FIRST NONZERO ENTRY IN THE ARRAY
NOTE      THIS IS USED TO FIND THE TIME OF THE FIRST DEFICIENCY
NOTE
      DO 10 J=1,120                                          SUB- 7
      IF (ARRAY(J).EQ.0.0) GO TO 10                          SUB- 8
      URGENCY=J                                              SUB- 9
      RETURN                                                SUB- 10
10 CONTINUE                                                SUB- 11
      URGENCY=120.                                          SUB- 12
      RETURN                                                SUB- 13
      END                                                  SUB- 14

NOTE
NOTE
X  REAL FUNCTION FSHIFT (ARRAY)
COMMON X(109),T(120),X1(196),X2(167),PRR1(10),X3(10)      SUB- 15
COMMON CF1(10),X4(30),TC2(10),PRR3(10),X5(10),CF3(10)      SUB- 16
COMMON X6(30),TC3(10),EPLAN(120),X7(684),APLAN(120)        SUB- 17
COMMON FMSA(120),X8(600),X9(601),WSPRR(10),Y(20)           SUB- 18
COMMON CP4(10),Y1(10),SP4(10),TC4(10),X12(2)               SUB- 19
DIMENSION ARRAY(120)                                       SUB- 20

NOTE
NOTE      FUNCTION FSHIFT MOVES EACH VALUE IN THE ARRAY FORWARD BY ON
NOTE      THIS IS USED WITH THE COMPUTED PLANS TO INPUT THE PLANNED
NOTE      SALES OR PRODUCTION AS THE TIME OF THE EVENT ARRIVES.
NOTE
      DO 10 I=1,119                                          SUB- 21
10  ARRAY(I)=ARRAY(I+1)                                     SUB- 22
      ARRAY(120)=0.0                                         SUB- 23
      FSHIFT=ARRAY(1)                                         SUB- 24
      RETURN                                                SUB- 25
      END                                                  SUB- 26

NOTE
NOTE
X  REAL FUNCTION DPR1 (A,B,C,TC,PRR,CF,TL)
COMMON X(109),T(120),X1(196),X2(167),PRR1(10),X3(10)      SUB- 27
COMMON CF1(10),X4(30),TC2(10),PRR3(10),X5(10),CF3(10)      SUB- 28
COMMON X6(30),TC3(10),EPLAN(120),X7(684),APLAN(120)        SUB- 29
COMMON FMSA(120),X8(600),X9(601),WSPRR(10),Y(20)           SUB- 30

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	COMMON CP4(10),Y1(10),SP4(10),TC4(10),X12(2)	SUB- 31
	DIMENSION TC(10),PRR(10),CF(10),TL(120)	SUB- 32
NOTE		
NOTE	FUNCTION DPR1 IS DESIGNED TO COMPUTE THE LEAST COST TRADEOFF	
NOTE	BETWEEN LEVEL OF EFFORT AND SCHEDULE DELAYS.	
NOTE		
	MTC=TC(1)	SUB- 33
	DO 10 I=2,10	SUB- 34
	IF(TC(I).GE.MTC) GO TO 10	SUB- 35
	MTC=TC(I)	SUB- 36
	DPR1=PRR(I)	SUB- 37
	DCF(N)=CF(I)	SUB- 38
	DTL(N)=TL(I)	SUB- 39
10	CONTINUE	SUB- 40
	RETURN	SUB- 41
	END	SUB- 42

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